THE ENGINEER

DECEMBER 5, 1952

The Guggenheim Medal, 1952

IT was the unanimous decision of the Daniel Guggenheim Medal Board of Award that the Guggenheim Medal for 1952 be awarded to Sir Geoffrey de Havilland, and this week in New York City, Sir Geoffrey was formally presented with the award on the occasion of the annual meeting of the American Society of Mechanical Engineers. The citation refers to Sir Geoffrey's " forty years of pioneering in military and commercial aircraft and the development of long-range jet transport." The board was composed this year of twenty-five persons who are either past winners of this award residing in the United States, or representatives of the American Society of Mechanical Engineers, the Institute of Aeronautical Sciences, and the Society of Automotive Engineers. The representative from England was Major Frank Halford. The medal was established in 1928 by the Daniel Guggenheim Fund for the promotion of aeronautics. It is one of the most coveted aviation awards of the United States. Sir Geoffrey, in expressing his profound appreciation, referred especially to the honour which had been done to all the members of the de Havilland companies, as well as to himself, and acknowledged the award to be a notable mark of recognition of the work which had been accomplished by all around him. He recalled, as if only a few years ago, how it was the example of the Wright brothers' first flights at Kitty Hawk in 1903 which filled him with an overwhelming desire to fly and led him on to his own ventures. Sir Geoffrey de Havilland was the founder of the de Havilland Aircraft Company, Ltd., and has been technical director of the Company since its formation in 1920. He is a director also of all the principal subsidiary companies in England and in the British Commonwealth overseas. He has devoted his working life to aeronautics since 1908, when, as a young man of twenty-six he left a position on the design side of the motor industry in London in order to build an aeroplane and achieve fully controlled flight.

Building Research in 1951

AN account of the work of the Building Research Station during 1951 is given in a recent report of the D.S.I.R. entitled "Building Research, 1951," and published by H.M. Stationery Office. A great deal of interesting research was in progress during that year, much of it of direct interest to the engineer. For instance, a number of investigations concerned with the design and performance of structures were in progress, including a theoretical and experimental investigation on steel-concrete bridge deck systems, and work on the strength of load-bearing concrete walls. An examination of the properties of hard-drawn steel wire of the kind used extensively in prestressed concrete was in progress, particular attention being paid to the behaviour of the wire under sustained loading. Investigations concerned with steel structures included an appraisal of the stiffening and strengthening effect of the concrete used for encasing structural steel for fire protection, with the idea of promoting some economy in the use of structural steel, and with the same end in view, an analysis of how loads are distributed between the steel frame and the walls and floors of a steel-framed structure. Other studies on structural engineering included in the report are devoted to " movement " joints in water-retaining structures, concrete tanks for oil storage, vibrations in structures, the compaction of concrete by vibration, and photo-elastic stress analyses. Soil mechanics work included further investigation on the short-bored pile and on houses built on clay soils, whilst the load bearing capacity of the foundations of large structures of various kinds formed the subject of a number of model tests in the laboratory and full-scale loading tests. The stability of earthworks was investigated with particular reference to seepage flow in a sheeted excavation in a cohesionless soil. The measurement of pore-water pressure—a convenient guide to consolidation and hence of the increase of strength with time—was undertaken at the sites of three earth dams. The development of apparatus for measuring earth pressures and the stresses in tunnel linings was also undertaken. Apart from these various problems, the Building Research Station also carried out work on building materials and building operations, and on the efficiency of buildings and the requirements of their users; the report concludes with notes on the Scottish Laboratory, Colonial investigations, and various special investigations.

The South Wales Tinplate Industry

SPEAKING at a dinner at Port Talbot, Glamorgan, last Saturday evening, Mr. E. H. Lever, chairman of the Steel Company of Wales, Ltd., announced that the Iron and Steel Corporation had approved a further scheme for modernising the tinplate industry in South Wales. Mr. Lever said that the principal part of this new scheme was the erection, by the Steel Company of Wales, Ltd., of a five-stand cold reduction mill at Velindre, Llangyfelach, near Swansea, similar to that which had recently gone into operation at Trostre. Other developments included the construction of additional coke ovens, extensions to the sintering plant, a fourth blast-furnace, four open-hearth steel furnaces, rolling mill equipment, and ancillary plant at the company's works at Port Talbot. Furthermore, additional annealing, temper-pass and tinning plant would be installed at Trostre. Mr. Lever indicated that, at present prices, the whole programme might be expected to cost approximately £40,000,000, and he also said that the estimated production of the new works was about 8,000,000 boxes of tinplate a year. The decision to proceed with this programme was timely, Mr. Lever continued, for world trading conditions were changing rapidly, and he considered it to be of paramount importance that the total modernisation of the tinplate industry should be pressed on with all speed. Mr. Lever added that, until the new extensions were operating, a large output from the company's old plant would still be required. He said that any problems of redundancy of labour which might arise from the ultimate closing down of the old plant would be a matter of consultation between the company and the trade unions concerned.

Return of Shipping Casualties

THE Ministry of Transport has issued its *Return of Shipping Casualties and Deaths*, 1951, for vessels registered in the United Kingdom. According to the report, in 1951 a total of 35,581 gross tons of power-driven vessels, other than fishing vessels, was lost, and this total was 13,609 gross tons less than the previous year and the second lowest figure on record. During the year no passenger ship or oil tanker was lost; a tabular statement gives the tonnage losses for the years 1938, 1946–1951 as a total and as a percentage of the total tonnage on the Register, the figure for 1951 being 0·19 per cent. Another table in the report lists the number of ships, and their gross tonnage, which had suffered serious casualty during the years 1946–1951. The total for 1951 was fifty ships of 205,753 gross tons, which represents a reduction of fifty-nine ships and 264,053 gross tons from the 1950 returns. Minor casualties to power-driven vessels, reported to the Ministry of Transport, are stated to total 2397 and represented an increase of 131 over 1950. A list is given of the formal investigations in casualties ordered by the Ministry and there is a statement upon the loss of life. Yearly averages for the number of deaths for various causes are listed for 1934–1938, 1946–1950, together with the figures for 1950 and 1951. The total deaths in 1950 and 1951 were 610 and 552 respectively. Power-driven fishing vessels totally lost number twenty-four, two less than the previous year, while thirty-three vessels suffered serious casualty compared with fifty-seven in 1950. Included in the return is a table giving the number of power-driven vessels (other than fishing vessels) of 100 gross tons and over registered in the United Kingdom and grouped according to tonnage class and age. Other tables set forth in detail the causes of the various casualties, including the tonnage class and age of the ships involved and an analysis of the causes of the loss of life.

B.E.A. Midlands Division Controller

WE learn from the British Electricity Authority that Mr. R. L. Batley, A.M.I.Mech.E., chief generation engineer (operations) of the Merseyside and North Wales Generation Division of the British Electricity Authority, has been appointed controller of the Midlands Division in succession to Mr. F. W. Lawton, M.I.E.E., M.I.Mech.E., A.C.T.C., who is to retire at the end of the year. Mr. Batley studied at Liverpool University, Bradford Technical College and the Regent Street Polytechnic, and, after serving a mechanical engineering apprenticeship at the Cunard engine works, became a marine engineer with the Cunard Steamship Company, Ltd. He subsequently held power station appointments at Bradford, Hackney, and later at Neasden, where he became resident engineer. In 1944 he was appointed generation engineer with the Swansea Borough Council, having charge of the management of the Tir John station, and then, in 1947, became superintendent engineer of generation of the Liverpool Corporation Electric Supply Department. He was appointed to his present position on the establishment of the British Electricity Authority in 1948. Mr. Lawton, after technical study at Northwich and King's College, Newcastle, began his engineering training with W. E. Bates and Sons, Northwich, and continued his training at the Heaton Works of C. A. Parsons and Co., Ltd. He then entered municipal service as assistant to the city electrical engineer, Stoke-on-Trent. Soon afterwards he went to Birmingham, where he was engaged on power station design, operation and testing. Subsequently he became special technical assistant, chief assistant engineer and, later, deputy chief engineer and manager of the electricity undertaking. He was appointed chief engineer and manager in 1944 and held this post until 1948, when, with the reorganisation of the industry, he became controller for the Midlands Division. Mr. Lawton has taken a special interest in power station design and construction and has been responsible for the construction of Hams Hall " A " and " B," Nechells " B " and the new Drakelow " A " power stations.

Trans-Canadian and British Railway Experiences

By EDWARD H. LIVESAY

No. IV—"THE INTER-CITY LIMITED"

(*Continued from page* 713, *November 28th*)

The author has made a number of recent journeys on Canadian and British Railways and his reminiscences of these trips are set out in this series of articles. They began with a comparison of the two transcontinental railways—Canadian National and Canadian Pacific—giving an account of a journey from Victoria to Vancouver via Nanaimo, C.P.R., and another from Vancouver to Toronto on the C.N.R. Here he deals with a run from Toronto to Montreal.

THERE are not many fast trains in Canada; that is to say, trains covering several hundred miles at an average speed of 45 m.p.h. or more. However, "The Inter-City Limited" and "International Limited" certainly come into this category and stand at the top of the list; the former runs from Toronto to Montreal and the latter in the reverse direction. These two trains are somewhat similar to certain British services between London and Scotland, such as the "Royal Scot," the "Capitals Limited," and so on, inasmuch as they are all day trains covering comparable distances. Naturally, there is a good deal of traffic between Toronto, with a population approaching a million, and Montreal, with upwards of a million and a half, the largest two cities in Canada. Though nowadays much of the traffic goes by road and air, there is a good deal left for the railways, the C.N.R. and C.P.R., which between them provide three routes, all much the same, the C.N. double-tracked and the C.P. lines single most of the way, being double only for 144 miles from Montreal to Glen Tay. Here they diverge, one route more or less following the shore of Lake Ontario and paralleling the C.N.R., the other swinging inland to the north through Tweed and Peterborough, they "marry" again at Agincourt, 13 miles from Toronto. The C.N.R. line is 335 miles in length between the terminal cities, and the shorter of the C.P. routes, via Belleville, Port Hope, &c., is 340 miles.

Twenty years ago or thereabouts both companies for a while indulged in cut-throat competition for the lucrative traffic between these two great urban centres, frequently speeding up their trains in an attempt to keep ahead of each other, very much as the East and West Coast lines did during the race to Aberdeen in 1895; but finally, realising that co-operation would result in bigger dividends than competition, they agreed to bury the hatchet and "pool" everything, traffic, equipment and receipts, the only sensible thing to do. The climax was reached in 1930, when the C.N.R. "International Limited" made the Montreal-Chicago run, 851 miles, at 45 m.p.h.,* the first part, to Toronto, 335 miles being covered in six hours flat, at 56 m.p.h., and claimed—for all I know correctly—this to be the fastest train over a like distance in the British Empire. The C.P.R., not to be outdone, though hampered by a single-track line over which similar speeds were not possible, drew attention to the fact that their train covered the first division, double tracked, to Smiths Falls, 127 miles, at an average of 66 m.p.h., and asserted that *that* was the fastest in the Empire over a comparable distance. It may have been; I would not dispute it, and will leave the timing and measuring experts to fight over it. In any case the C.P.R. wore the laurels until the "Cheltenham Flyer" was crowned in its turn, only to hand over the chaplet to the "Silver Jubilee" in 1935, I believe.

The result of the "pooling" at first was the "International" running in both directions between Montreal and Toronto in 6½ hours; this was before and during the war; now it is the "International," westbound to Toronto, from whence it continues to Chicago, and the "Inter-City Limited," eastbound to Montreal, both trains doing the journey in fifteen minutes less. At Montreal they use the C.P.R. Windsor Station, and that company's line to Dorval, where they switch to or from the C.N.R.'s double-track main line via Brockville and Belleville into Toronto's Union station; the latter railway supplies the motive power, and both companies jointly the rolling stock. The arrangement is very sensible, in cutting out wasteful competition and utilising the C.N. double track, which is more suitable for fast running than either of the C.P. single lines. If I dare say so, the same thing applies to the motive power, as the C.P. "Hudsons," with 6ft 3in drivers, splendid engines though they are, probably would be no longer capable of handling either of the "Limiteds," timed and loaded as they now are.

When competition was the order of the day, before "pooling" was adopted, the C.N.R. built five "Hudson" engines expressly for the super-fast "International" train, and in THE ENGINEER of December 5, 1941, I described a through journey on one of them, No. 5704, from Montreal to Toronto. These fine engines, with their 6ft 8in driving wheels, ample boiler power, grates, and high pressure, were at that time among the most impressive locomotives in Canada, and were fully capable of handling the "International" of that day, with its 750-ton loading and the 65 m.p.h. average speed originally called for. But as is so often the case where an engine is designed to do specific duties and care is taken to give it what is considered a good margin for eventualities, conditions change, and increasing demands are made upon the engine that it can only meet under favourable circumstances; in short, the willing horse is overloaded. So it was with the "5700s"; the loads became progressively heavier and the speed, at first cut when "pooling" was adopted, returned later almost to the original figure, until these capable engines, notwithstanding their 43,300 lb tractive effort—plus 10,100 lb provided by the booster—were unable to meet the demand when that little extra was asked from them in emergencies—due to weather, station delays, a spot of mechanical trouble, and so on. The 4–8–4s were evidently the only solution; they duly appeared, and the "6200s" now reign in their stead—with diesels getting ready to come on the stage in the near future. The chief dimensions of both classes are given below.

	No. 5704, "Hudson," 4–6–4	No. 6200, "Mountain," 4–8–4
Cylinders	23in by 28in	25½in by 30in
Driving wheels	6ft 8in.	6ft 1in
Heating surface	4842 sq ft	5915 sq ft
Superheater	1465 sq ft	1835 sq ft
Grate area	73·6 sq ft	84 sq ft
Steam pressure	275 lb	250 lb
Tractive effort	43,200 lb	45,000 lb
Ditto, booster	10,100 lb	12,000 lb
Factor of adhesion	4·36	4·33
Weight :		
Engine	159 tons	180 tons
Tender	130 tons	124 tons
Coal	18 tons	18 tons
Water	14,000 gallons	11,600 gallons
Firing	Stoker (B.K.)	Stoker (B.K.)
Valve gear	Baker	Walschaerts
Feed	Exhaust steam injector	Pump and feed water heater
Bearings	Roller trucks	Roller throughout

The C.N.R. Toronto roundhouse is some way from the station; I was driven there an hour or so before train time by a courteous official—whose name I have churlishly forgotten—in order that I might meet some of the locomotive people and make the acquaintance of the engine while it was reasonably quiescent, before it was goaded into turbulent eruption on the train. It happened to be No. 6200, 4–8–4, the first of the class, and by a happy chance No. 5704, on which I had ridden from Montreal with the "International Limited" on a previous occasion (THE ENGINEER, December 5, 1941), was standing alongside. Both engines looked in perfect condition, and it was hard to realise that No. 5704 was over twenty years old, and had probably travelled a million and a half miles at high speed. Both engines were clean; *really* clean; it was a joy to see locomotives so well groomed and cared for. I did not realise, when looking at these spotless machines, how much I should miss seeing British engines in like condition and how few of them there would be.

Looking round the engine with the super-

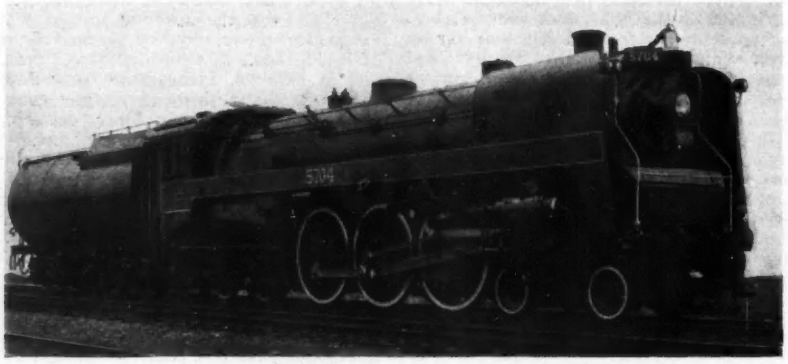
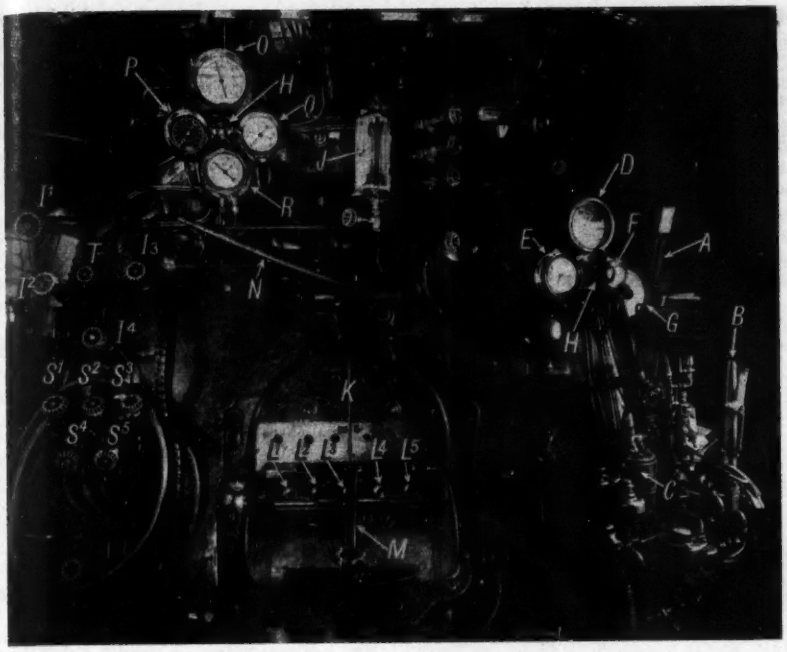


Fig. 15—Express Locomotive No. 5704, C.P.R.

* It now does the journey in 16½ h, at an average speed of 49 m.p.h., inclusive of stops.



A. Multiple throttle
B. Reverse, air-operated " Barco "
C. Brake valves
D. Booster gauge
E, F. Brake gauges
G. " Kent " revolving window
H. Electric light
I (1, 2, 3, 4). Injector controls
J. Water gauge (protected)
K. " Franklin " firedoor, air operated
L. Air holes, through which fuel feed can be watched. B.K. stoker
M. Fuel deflector
N. Hand lever, firedoor
O. Steam gauge
P. Stoker gauge
Q. Steam heat gauge (train)
R. Feed water heater
S (1, 2, 3, 4, 5). Stoker steam jets
T. Blower

Fig. 16—Cab Fittings and Controls, " 6400 " Class

intendent, I inquired casually how she might be expected to ride ; I felt that almost anything might transpire on a small-wheeled, eight-coupled engine travelling at 80 m.p.h., and there was going to be plenty of opportunity, too—335 miles of it. From the superintendent's enthusiastic reply it seemed I might set my mind completely at rest on the matter; it would be like reclining on a featherbed ; I should think I was in the train ! Was not No. 6200 one of the latest class, with the best suspension, in fine condition, with roller bearings (" What's that got to do with it ? " I said *sotto voce*) ; and was not the best piece of track on the company's system going to be the venue ? Ride, forsooth ! Why, I shouldn't be *riding* at all —I should float ! Alas, this eulogy, while doing credit to the superintendent's heart, if not to his head, failed to convince me—I felt sure he was drawing a long bow. I looked at the engine, and though outwardly simulating the keenest pleasure at what supposedly was in store for me, inwardly I pictured myself looking for something soft to sit on long before we reached Montreal. How could it be otherwise ? Given a pair of 25½in by 30in cylinders, with heavy motion, connected to eight-coupled 73in wheels (Fig. 17) revolving some of 400 times per minute, and one would have to be a real optimist—or an ignoramus—to expect anything but a pretty rough passage. And that is exactly what it turned out to be, but I anticipate.

Climbing determinedly into the cab, I found Enginemen Hunter and Cot already there ; we were joined shortly after by Master Mechanic Cooper (*Anglice* : Inspector), who was coming part of the way with me " to see you shake down all right," it was explained. As if I needed a master mechanic for that—the engine would undoubtedly do all the shaking down necessary. M.M. Cooper was an ex-G.W.R. man, nearing retirement ; he began his railway career under Churchward in 1904, firing " Stars " and the de Glehn compounds. I wonder how many more British railwaymen I shall come across in Canada still following their old profession and almost invariably doing well in it ? Only a few months before I had found another ex-G.W.R. man, Engineer Gilkes, in the cab of the C.P.R.'s last steam locomotive, No. 5935, taking the " Dominion " westward through the mountains to Field ; he, too, was nearing retirment.

The weather was warm and fine, but ominously dull; as No. 6200 left the yard for the depot Cooper drew my attention to the flashing beacon on top of the Canada Life Building, which broadcasts weather probabilities by means of coloured lights. I was told 150 engines are cared for in the yard, in which there is a soda-ash water-treatment plant. Fig. 16 shows what is seen in the cab, and though this is actually the back plate of a " 6400 " class engine, there is so little difference in the arrangement of modern Canadian engines it will serve well enough as a guide ; things are almost standardised on North American locomotives, so far as controls go.

Three arch tubes and two siphons support the brick arch, and grate shaking is done by hand ; electric light is provided inside and outside the cab and a lamp is placed below the running board by the injector overflow pipe, a useful fitting, and there are lamps over both seats that can be switched on and off as desired. The steam turret is outside the cab, as it should be ; there is apt to be plenty of warmth in the cab in summer without a complicated turret acting as a radiator. The galaxy of controls looks complicated, but they are all necessary on a large engine with many auxiliaries—booster, power reverse, stoker, firedoor, feedwater heater, &c.—and they are so conveniently placed that neither engineman need leave his seat under normal running conditions. The vestibule cab is a natural concomitant of the Canadian winter ; steam heating and footwarmers are equally appropriate. There are four seats, two being of the " drop " pattern, the one behind the fireman being for the head brakeman, who rides in the cab when the engine is employed on freight work ; the other comes in useful when there is any sort of a supercargo on board. Neither proved very valuable to me, as things turned out ; owing to the weather conditions I could not see anything from them worth mentioning, and I seldom can write legibly in a cab sitting down.

The " 6200s " are a development of the preceding " 6100s " and, like all the eight-coupled classes with 6ft 1in wheels, are really mixed-traffic engines. Though eminently suitable for fast freight work, in which they handle trains weighing 2000 to 3000 tons at 60 m.p.h., they can be and are used on high-speed passenger services, too, such as the " Inter-City Limited." The experience gained with the earlier classes led to many detail improvements in the "6200s," such as Timken roller bearings, larger steam and dry pipes, increased port areas, and so on, resulting in easier steam flow and cylinder efficiency at high speed. Baker valve gear has given place to Walschaerts, but long valve travel remains one of its chief features. Floating bushes are fitted to the crankpins, and some degree of controlled lateral motion is allowed to the leading coupled axle by the Alco device ; the coupled wheel centres rea of the " Boxpok " pattern. Boiler feed takes place via an " Elesco " feed water heater, seen in front of the stack, with its pump on the left side over the rear coupled wheels. The boiler, 7ft 6in in diameter at the largest of three rings, is of silicon steel and the firebox is fitted with two siphons and three arch tubes, all being used to support the brick

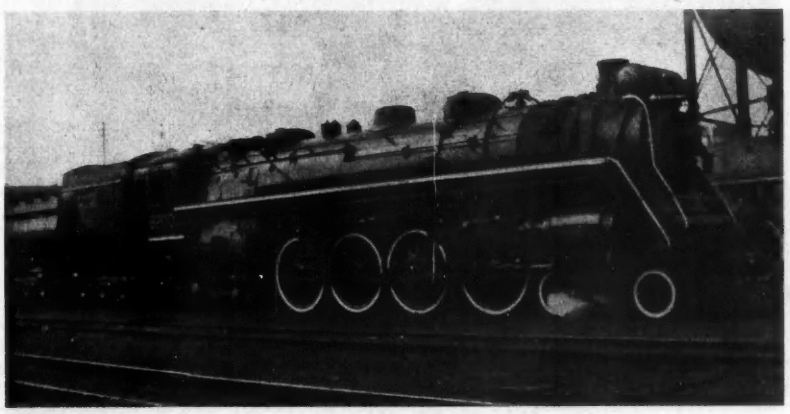


Fig. 17—No. 6200 " Mountain " Class

arch, and the superheater is a Schmidt. The Vanderbilt tender has a cast steel tank bottom, making a separate frame superfluous.

Watching preliminary movement about the yard—to the coal chute, water tank, and thence to the station—one could not help being struck by the ease with which a big engine such as No. 6200 is handled. The power reverse gear, for instance—no physical effort is required to run it the full distance front to back, a matter of two or three seconds, and a pointer moving over a quadrant in front of the driver makes positioning accurate and evident ; he can see what he is doing by day or night, aided by electric light. The throttle naturally does need some muscle work, but it is of multi-valve design, with a hanging to-and-fro handle, so even that is made as easy as possible. The cab is roomy, too, a loading gauge of 10ft 10in by 15ft 8in being responsible for that. Wind deflectors beside the windows, of course, and padded arm rests ; I did not notice linoleum on the deck—one has to ride a diesel for that ! Nor a toilet—same qualification. And so to the Union Station, convinced the trip was going to be interesting, and resigned to the bucketing I knew was in store for me. Six and a quarter hours in which to " shake down."

Toronto's Union Depot is both æsthetically and practically very much what a big station should be. It is the outcome of long years of much argument about it, the inconvenience, to use no stronger term, arising from the old station and track layout, sprawling, as they did, right across the approaches to the busy waterfront, with their accompanying " grade crossings," interrupting traffic, whether or no there were gates—dangerous and commercially out of date. In the end, agreement between the railways and the city was reached, the present layout solving the problem, all streets being taken under the tracks and a fine modern station was constructed. Fig. 18 shows the upper concourse and ticket hall, from which a wide ramp slopes down to a lower gallery, giving access to the platforms, these being on a lower level. As will be seen from the picture, the ticket hall is a spacious and imposing place, architecturally typical of the pre-war age, when a dollar was worth twice what it is now and something more than pure utilitarianism often came into the design of public buildings. One doubts whether quite such a majestic style would be considered nowadays, as, after all, such things cost money, and however delightful it may be to take one's ticket in a cathedral, and deposit one's baggage in marble halls, it does not get one to one's destination any quicker. My only criticism of the Union station is that all the decorative art has been expended on the upper works, the actual platform area being modelled somewhat on the lines of a Nazi U-boat shelter—severely utilitarian, irradiated by a " dim religious light " shining coldly down vistas of unrelieved concrete.

The train, standing in the station and already well-filled, was made up of fourteen cars ; allowing roughly 80 tons per car, a fair estimate, plus 2½ tons of ice for air conditioning, passengers, baggage, mail and express (parcels), we figured the load was over 1000 tons. " Train orders " having been handed up to the engineer by the conductor, the latter went back to the coaches, and shortly after the plaintive bleat of the communication whistle sounded in the cab and the " Inter-City Limited " moved out of the station at 4 p.m., No. 6200 getting a firm footing after the barest suspicion of a slip. There are advantages in an eight-coupled engine with 148 tons available for adhesion, 56,785 lb of tractive effort and a factor of adhesion of 4·33 ; it takes a good deal of careless handling to make that sort of engine slip. Acceleration at first was good, but No. 6200 was checked almost immediately by a " slow " order of 20 m.p.h., extending for 2 miles, due to the construction of Toronto's subway—Underground—right alongside the railway. Toronto is eagerly awaiting the completion of this undertaking, which is scheduled for 1953, and is tearing up streets all over the city ; it will be the first underground railway in Canada. The line will run beneath many of the chief thoroughfares, excavation being near the surface, cut-and-cover work ; it is not a deep-level tube. Many street car routes have been put out of commission that the work may proceed, and the cars have been switched to other streets.

The 20 m.p.h. restriction ended at the foot of the great Scarboro bank, which extends for approximately 8 miles, disregarding a brief " rest-and-be-thankful " two-thirds of a level mile, about halfway up ; the profile is shown by Fig. 19. At the third milepost (from Toronto) the speed had risen to 45, and here the real climb began, 2½ miles of 1 in 100 ; it was taken on full throttle with 60 per cent cut-off, the train passing over the peak at 40, time 4.20 p.m., a good effort with 1000 tons trailing ; No. 6200 was probably going " flat out." The boiler was unaffected, the climb beginning and ending with the gauge needle steady just below blowing-off point, 250 lb. Immediately beyond the summit, on a preliminary mile of gently falling and level going, Hunter made a running test of the brakes before beginning to drop down the 5 miles of 1 in 100 ; during the brake application the speed was about 60, but after release it was allowed to reach 80 on the descent, which is the limit over the whole distance to Montreal. In the competition years, when the two companies were daily making strenuous efforts to cut each other's time, higher speeds were often hit and held, notwithstanding the numerous " grade crossings," but municipal authorities objected, as well they might, so when the traffic was " pooled " and the heat of the conflict died down, a maximum of 80 was set for the whole line, at which it remains.

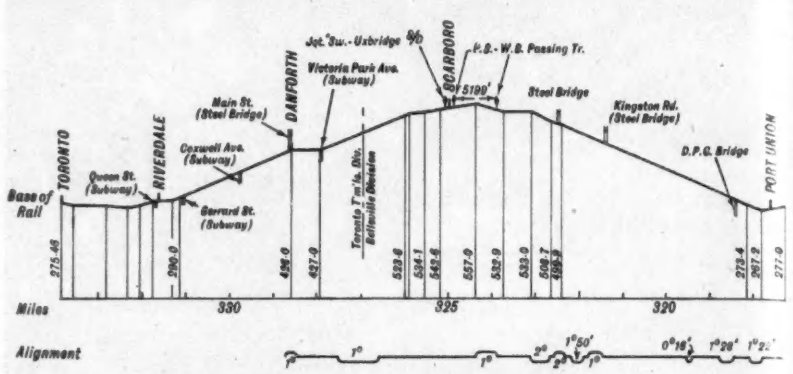


Fig. 19—" The Inter-City Ltd "—The Scarboro Incline

Port Union, at the foot of the descent, was passed at 4.27 p.m. and 75 m.p.h.; 16 miles in 27 min from a standing start, with 2 miles' restriction to 20 m.p.h., followed by 4½ miles of 1 in 100 up. A few minutes later we swept through Pickering in pouring rain, so heavy the side windows had to be closed, making it very noisy in the cab ; an occasional remark had to be literally bellowed to the crew, and even then often failed to get through ; they would bellow back—that hardly ever got through. At high speed the riding was just what I had anticipated, rough and rugged, and writing was very difficult, even standing up, a good criterion of an engine's behaviour. The rain was becoming torrential, completely blotting out the landscape and reducing visibility to a few hundred yards. Note-taking was much affected, as I could see next to nothing outside the cab and hear nothing inside but the thunderous roar of the lurching engine, the noise being intensified at frequent intervals by the deep chime whistle. For a while I was reduced to watching idly through the air-holes below the firedoor the coal being

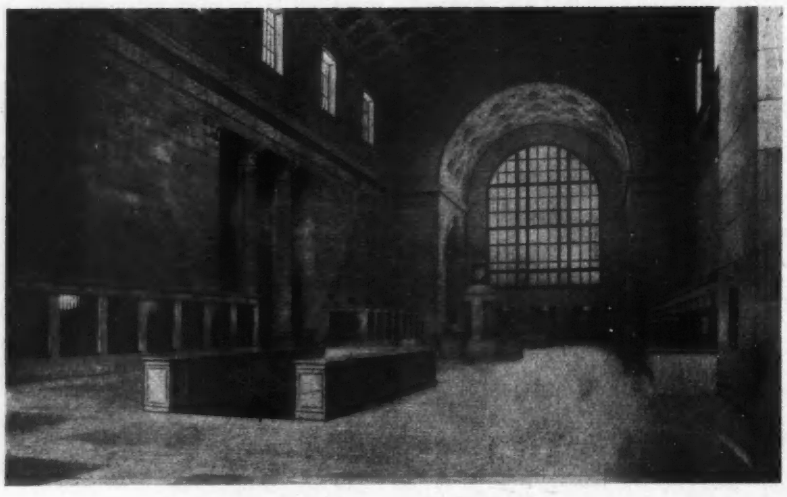


Fig. 18—Upper Concourse Ticket Lobby, Union Station, Toronto

steadily, relentlessly pushed on to the feed plate, to be picked up and whirled to a fiery death in the white vortex of flame that raged in the firebox. I did not trouble to look at any of the gauges ; thanks to an ample boiler and mechanical stoking, the needles were always about where they should have been, and any corns the fireman's labours engendered were likewise about where they should have been—and that was not on his hands.

The first stop was made at Oshawa, 4.42 p.m., where water was taken, the halt lasting 6 min ; average so far 49·3 m.p.h. If anything, it was raining harder than ever ; gardens and streets nearby were flooded, and just beyond the station the water was right across the track. The restart was at 4.48 p.m., and soon the " Inter-City Limited " was again roaring through the grey curtain of water, past flooded fields, some dotted with hay bales, others a tangled mat of lodged and sodden grain, much of which was sure to prove a total loss. And this was mid-July ! I have certainly never seen anything like it in Ontario ; it was the very antithesis of conditions in B.C. from, whence I had come ; there next to no rain had fallen for three months. There seemed a certain left-handedness about the Continent's summer weather that it was difficult to approve of. However, it had no effect on No. 6200.

Newcastle was reached at 5.02 p.m., and Port Hope at 5.15 p.m., 2 min late. Nothing of importance was happening in the cab ; the steam gauge needle seemed glued just below the 250 lb mark, the water level was always surging about two-thirds up the glass, and the fireman just sat at ease—more or less—on his stuffed seat, leaving to the feed pump and stoker engine the task of keeping water level and steam pressure at the appropriate points. The look-ahead was hopeless—there were no window wipers on this engine—but on 7 miles of mostly falling gradient approaching Port Hope, where there was a 3 min " flag " stop, the speed seemed the highest yet, a good 80 m.p.h. Again I noted " riding very rough," and the proof is now to hand, as it is only with the utmost difficulty I can decipher things in my notebook. Colborne was passed all out at 5.38 p.m.; station names were hard to read through the rain-fogged windows, and sometimes I missed them altogether. It was generally useless to bellow an inquiry at the crew, because, as fate would have it, on the rare occasions when they understood me I was sure to misunderstand them—the roar of the engine overmastered us. Lightning, too, began flickering through the wall of water, but one could hear no thunder ; the deepest diapason of the elements failed to make an impression above the rumbling clamour of the engine. And always that penetrating whistle. It would be sure to intervene and complicate things just at the moment that found me trying to blast a question into the fireman's ear, and I would break off, the subsequent remarks having no bearing whatever on the previous conversation. The whistle, by the way, may not be used in city limits except in emergency, but its use is obligatory approaching level crossings.

At Trenton we were 5 min late, and, if possible, the weather was worse than ever. One looked through semi-opaque windows into a fog of rain upon which lightning flickered eerily. But the speed remained high, 75/80 ; for 25 miles or so following Cobourg the track was unusually free of curvature, but changes of gradient were incessant, and the profile supplied by the company shows why this is. It is evident that the line was originally built as cheaply as possible, the permanent way following the natural contour of the ground, only the minimum cutting and filling being undertaken. The engine took most of these little variations in its stride, and the engineer paid no attention to them, only major and lengthy gradients calling for throttle and valve travel alteration.

Belleville, the first divisional point, entailed a stop, 5.52 p.m., and a mile or so farther along another, for coal and water ; between them they occupied 23 min, the final restart taking place at 6.15 p.m., 14 min late. The crews changed here, the name of the incoming engineer being Casey. One hundred and fourteen miles had been covered from Toronto in 112 min, two stops totalling 9 min

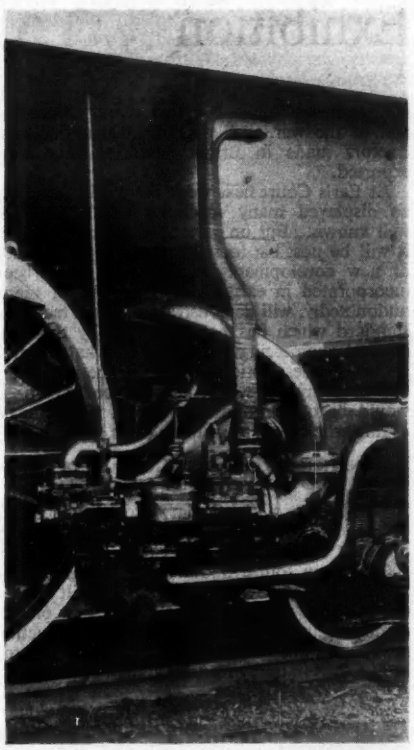


Fig. 20—Exhaust Injector as Fitted to " U1 " Class

inclusive, 61 m.p.h., in vile weather and with a 1000-ton load. Servicing was done here, a " ground crew " looking after most of the lubrication, using grease guns, some of which are power operated from the air brake supply. Other roundhouse men attended to the ash-pan, rocking the grates, if necessary, the engineer only looking after certain points that can be satisfied with an oilcan. M.M. Cooper left at this point, but two other enginemen came aboard in his place, making five people in all in the cab, too many for comfort and, I believe, against regulations, which limit the permitted number to four. Later I was to see six in a British cab at one time, and on a fast train at that, but wild horses will not drag from me where and when this was—somebody might get into trouble.

The gradient east out of Belleville has a rising tendency for several miles, but then inclination becomes more decided, with short stretches of 1 in 100 though most of them can be more or less " rushed." Several minutes had been picked up before Napanee, and by Ernestown yet more ; the rain, too, was easing up, and for some while No. 6200 had been putting in fast and heavy work, regaining all possible time before coming to a 20-mile stretch to Kingston, the next stop, along which there was much 1 in 100 gradient up and down, with frequent severe curvature, one of the toughest sections of the whole route. The whistle got in a good deal of its deadly work along here ; it is worked either by chain or trigger, the latter being handiest, and the engineer preferred it.

The " Inter-City " was 4 min late at Kingston ; the two passengers in the cab left, somewhat to my relief, as I could then more conscientiously use a seat. Water was again taken, and it was only raining slightly, but still a miserable evening, cold and unsummerlike. Kingston station is built on a curve, somewhat unusual in Canada ; we had covered the 47 miles from Belleville in 48 min, 59 m.p.h. The restart was at 7.08 p.m., in gathering dusk, so note-taking, at any rate of things outside the cab, would soon be impossible. It was consistently high-speed travel now, seldom under 80, for 25 miles or so, through Gananoque, Lansdowne, and Mallory Town. By Lyn Junction the rain had definitely ceased ; we were nearing Brockville, the second divisional point, just outside which a stop was made for coal, taken on in about 1 min ; then on into the station, arriving 7.54 p.m., 48 miles from Kingston in 46 min, 63 m.p.h.

After the usual servicing we left Brockville at 8.11 p.m., with Enginemen Ouellette and Duncan in charge. Some cars had been dropped for Ottawa via the C.P.R., and what with lengthy station work and the extra stop for coal we got away 15 min late ; it looked as though our chances of getting to Montreal on time were rather slender. It was dark by the time we reached Prescott, and I abandoned taking notes, except for an occasional entry made in the glare coming from the holes below the fire-door. No doubt the crew would have switched a light on for me had I asked, but I disliked doing this for fear of dazzle. There are really no gradients worth consideration from Prescott right into Montreal, and for 17 miles between Summerstown and Coteau there is no curvature either ; it is very much a water level route along here, and high speed was the order of the remaining day. Cornwall, the next stop, found us still 12 minutes in the red ; It was quite dark when we left, the train speeding along towards Montreal with the silver beam of the headlight tunnelling ahead into the blackness, making every trackside object stand out against inky shadow, yet failing to dim in any way the emerald green of the colour-light signals. Ouellette was still determined to recover those elusive minutes if it were possible, and said we were safe to do it " If it weren't for the 10-mile-an-hour slow over the Ottawa River—that'll play hell with our chances ! " This was shouted in my ear, and for once I caught the words. And that is what happened ; the long passage across the river—repairs were being made to the bridge—did cancel out any possibility of a scheduled arrival, despite all the fast running since Cornwall, most of it at 80, and a drastic slowing at Dorval, where switching from the C.N. to C.P. track " piled Pelion upon Ossa." So I was neither surprised nor disappointed when the " Inter-City Limited " came to a stand in Montreal West station at 10.10 p.m., in Westmount 10.17 p.m., and Windsor terminal at 10.22 p.m., 7 min late. It was to nobody's discredit and certainly not to that of No. 6200 ; the handicaps, had been too great. The 331 miles from Toronto to Montreal West had been covered in 370 min, but deducting stops, which added up to 53 min and without any allowance for slowing to stops and regaining speed afterwards, the average

speed was 62·6 m.p.h. The late arrival, only 7 minutes, was probably due to somewhat longer station work than usual. I do not think the weather had much to do with it, bad though it had been ; an engine such as No. 6200 has sufficient reserve power to offset such a minor hindrance as that, even when handling a 1000-ton train.

Chatting with Ouellette and Duncan beside No. 6200 while the "Inter-City Limited" discharged its burden of passengers, baggage and mail, I found them very interested in the "Capitals Limited," Britain's somewhat similar service, and much impressed by the latter's 392-mile non-stop performance. Ouellette laughingly suggested my making a trip on the footplate of the engine hauling that train, too, and comparing the running with that of the "Inter-City." It sounded a good idea, and I promised to bear it in mind when I arrived in England, and to send him a synopsis of the journey if it were made ; both things were subsequently carried out.

The next article will deal with the "Capitals Limited," running from London to Edinburgh.

(To be continued)

The Smithfield Show and Agricultural Machinery Exhibition

No. I

THE Smithfield Show and Agricultural Machinery Exhibition will open at Earls Court, London, on Monday morning next, December 8th, and will continue daily, from 10 a.m. to 7 p.m., until next Friday, December 12th. Since this exhibition was revived in 1949 —following the interruption caused by the second world war—the organisation has been undertaken by a joint committee representing the Smithfield Club, the Agricultural Engineers' Association, and the Society of Motor Manufacturers and Traders. This year's "Smithfield" will therefore be the fourth to be held at Earls Court, which has proved eminently suitable not only for the exhibition of cattle, sheep and pigs, but also for the extensive display of agricultural and horticultural machinery and implements and equipment for the meat trades which constitutes an increasingly important part of the Show.

At last year's "Smithfield" the number of cattle exhibited was small, owing to outbreaks of foot-and-mouth disease in various parts of the country and consequent restriction on the movement of livestock. At present, fortunately, this country is practically free of any such epidemic, which has taken such a serious toll of cattle this year, and next week it is expected that nearly 1000 animals—representative of famous herds—will be on show at Earls Court. The machinery exhibits, also, are more numerous than at the preceding shows. More than 350 manufacturers have taken stands, on which will be displayed up-to-date examples of tractors and agricultural and horticultural implements and machines of all kinds, together with an array of auxiliaries—such as oil engines, lighting sets and pumps—which are so essential to the efficiency of mechanised farming.

The Smithfield Show is the only exhibition of its kind which takes place annually in London. It attracts visitors from all parts of the United Kingdom, and every year an increasing number of overseas visitors pay close attention to all that is to be seen. The use of agricultural machinery is, of course, now at a far higher level than in the years prior to the war, and increasing mechanisation is a general tendency of modern times. Here agricultural mechanisation has probably been carried further in the last decade than in any other country in the world. It has been stated that in 1935 the value of the United Kingdom's production of agricultural machinery was in the region of £3,000,000 ; by 1949—when the first post-war Smithfield Show was held —that figure had advanced to £64,000,000, and last year it exceeded £100,000,000. These figures show that, even when allowance is made for the rise in prices, the increase in output of British agricultural machinery is a significant one. Not only has that output assisted the production of more home-grown food ; it is making a valuable contribution to this country's export trade. According to Captain E. N. Griffith, president of the Agricultural Engineers' Association, more than half of this country's tractor and farm machinery output has been sold overseas in the last two years. Since the end of the war, well over 425,000 agricultural tractors made in British factories have been exported.

At Earls Court next week there will naturally be displayed many machines which are now well known. But on several of the trade stands it will be possible to see entirely new products, or new developments, which have lately been incorporated in existing designs. All of them, undoubtedly, will demonstrate the high technical standard which has been achieved by the agricultural engineering industry. In what follows, we begin a description of some of the machinery and implements which are to be shown—it would be quite impossible within the compass of this article even to mention them all !

International Harvester Company of Great Britain, Ltd.

Two items of particular interest which are to be shown by International Harvester Company of Great Britain, Ltd., 259, City Road, London, E.C.1, are a four-cylinder diesel engine for the "Farmall BM" tractor which is built at the company's Doncaster works, and a new 6ft cut combine-harvester which is to go into production next year. The diesel engine, which is illustrated in Fig. 2, is in many respects similar to the firm's t.v.o. engine and a number of the components are interchangeable. It is a dry-liner engine, 4in bore and 5½in stroke, the piston displacement being 4325 c.c. The normal operating speed is given as 1450 r.p.m., enabling the tractor to develop a maximum of 38·20 belt horsepower and 34·36 drawbar horsepower. The fuel injection system employs a C.A.V. pump with four 8mm plungers and centrifugal governor, the nozzles having a guided stem, and glow-plugs built into the nozzle bodies. These glow-plugs work on a 12V battery operated system and are normally engaged for a period of thirty seconds before the starter motor is engaged, although the switch incorporates an automatic timing mechanism for presetting the heating period. The compression ratio is 16·5 to 1 and the opening pressure of the nozzles is 740 lb to 750 lb. The low-expansion alloy pistons have four rings, one of which is an oil control ring, situated above the gudgeon pin. The piston heads are recessed and the fuel is injected through an ante-chamber, the design of which, the makers claim, ensures a prolonged steady

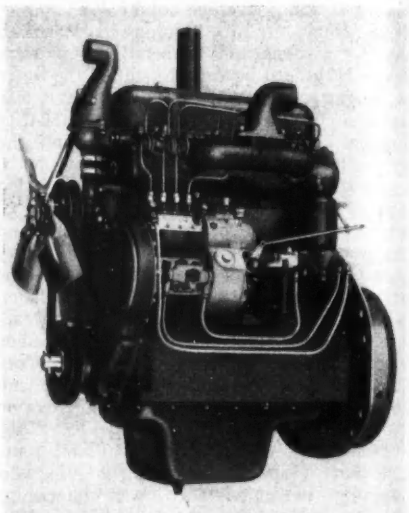


Fig. 2—Four-Cylinder Diesel Engine—International Harvester

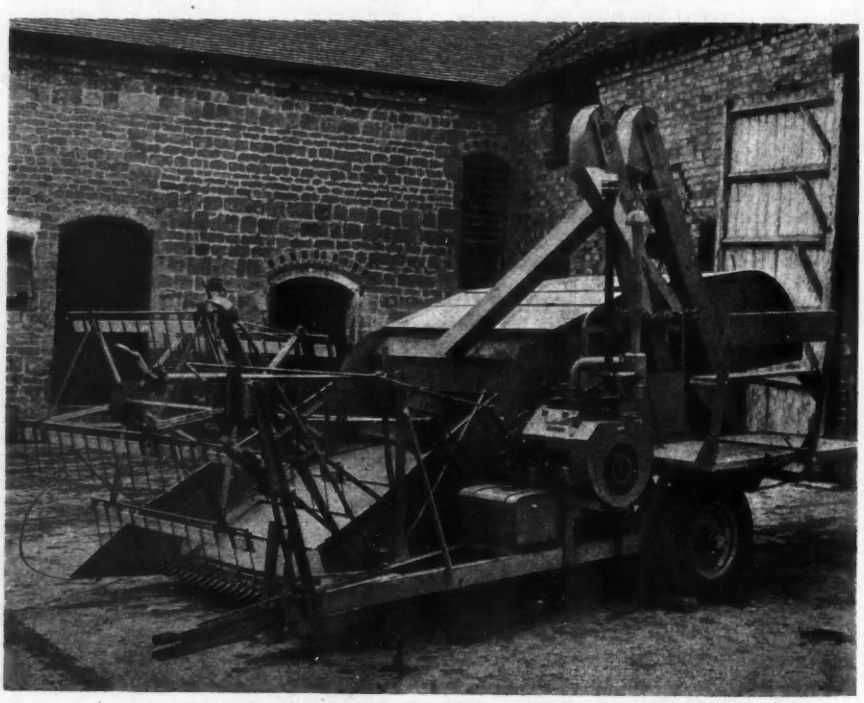


Fig. 1—Six-Foot Cut Combine Harvester—International Harvester

power stroke and smooth running. The use of glow-plugs also permits the employment of single-aperture injectors, thus minimising the possibility of "gumming up." The important matter of fuel cleanliness has been provided for by a "micronic" radial fin replacement filter supplemented by a water trap, the latter having a glass bowl so that the presence of foreign matter and water may be easily detected. It may be added that the firm has already begun production, at its Doncaster Works, of the new tractor incorporating the engine. The tractor is to be known as the "Farmall BMD."

The new combine-harvester, which is known as the "McCormick International B-64," is shown in Fig. 1. It can be appropriately described as a "straight-through" machine, which is the result of considerable experimental work in this country during the last two seasons. The overall length of the combine is 21ft and its width 9ft 6in, the height over the elevators being 10ft 2in. The knife has a full cutting width

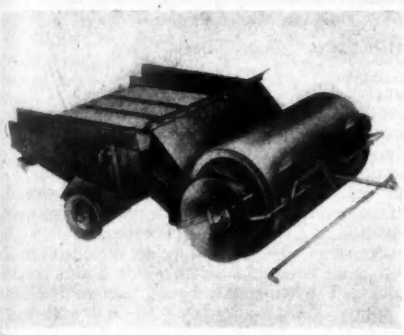


Fig. 3—Combine Harvester Cleaning Shoe—International Harvester

of 6ft and it is possible to control the cutting height between 2in and 35in. There is a single support reel—similar to that used on the company's self-binders—which is adjustable from the tractor driver's seat, and the cut crop is taken by a shallow, angled scoop feed, 5ft 4½in wide, which is provided with a canvas conveyor. The threshing cylinder, measuring 5ft 4½in by 1ft 3½in diameter, is of rasp-bar design, working with a concave grate, and is mounted on self-aligning ball bearings. The speed of the cylinder can be varied between 605 and 1300 r.p.m. The makers say that at this point up to 90 per cent of the grain separation takes place, the threshed grain falling straight to the grain pan and thus on to a chaffer sieve, which is one of the component parts of a shaker unit providing a total cleaning area of 1607 square inches. The unthreshed grain and straw pass from the cylinder beater on to a one-piece steel oscillating straw rack which has eleven fish backs to comb the straw apart, and which gives a separating area of 3690 square inches. The grain cleaning shoe is equipped with an adjustable top sieve, and there is provision for a second sieve or screen to be fitted underneath. The top sieve cleaning area is 1192 square inches. Fig. 3 illustrates the cleaning shoe and fan assembly, the six-blade, all-metal fan being of the under-shot design. The wind strength is regulated by the cone-shaped gates at either end of the fan housing and direction of the blast is controlled by a deflector. The new combine can be fitted either with a bagging attachment or a grain tank, the capacity of the latter being 21½ bushels. The machine is arranged for operation by power take-off from a tractor, or, as shown in Fig. 1, by a Petter air-cooled engine. V-belt drives are used throughout, with the exception of the reel, for which a chain drive is employed.

Bristol Tractors, Ltd.

In Fig. 4 we illustrate the Bristol "22" crawler tractor, examples of which will be exhibited by Bristol Tractors, Ltd., Earby, via Colne, Lancs. These tractors are now being produced in a variety of track widths and centres; there are eleven alternative overall widths and eight different track centres. The two machines which are to be shown next week are a 44½in track centre, 54½in overall width with 10in track, and a 30in track centre, 37in overall width with 7in track. The overall length of the tractor is 7ft 11½in and its ground clearance is 14in. It is powered by an Austin "A-70" four-cylinder industrial engine, 3½in bore and 4½in stroke, which develops 22 b.h.p. at 1500 r.p.m. The drive is taken through a Borg and Beck 9in single-plate clutch and the gearbox provides three forward speeds of 1·8, 2·85 and 5·85 miles per hour, and a reverse speed. The layshaft is extended to drive the four-cylinder hydraulic pump and also carries a sprocket for driving the power take-off shaft through duplex chain. Lever-operated clutches and foot-operated brakes control the steering. The full-length track units incorporate four pairs of roller wheels each side, with top jockey wheels to give the maximum stability. The roller mounting and idler assembly is designed with the front idler spring loaded to safeguard the track and track mechanism against the entry of stones. Each pair of roller wheels is mounted on taper roller spindles. The maximum drawbar pull of the Bristol "22" is stated by the makers to be 4000 lb.

Ford Motor Company, Ltd.

At last year's Smithfield Show, The Ford Motor Company, Ltd., Dagenham, Essex, introduced the "New Major" tractor, which was described and illustrated in our issue of November 30, 1951. This tractor, it will be recalled, offers a choice of three engines—diesel, petrol and vapourising oil. This year, the Ford Motor Company, Ltd., is to exhibit a commercial model of the "New Major." In most respects it follows the design of the agricultural version, though some refinements have been included to suit the tractor to haulage and other industrial purposes. In the commercial model a choice of diesel or petrol engines is offered, developing 40·5 b.h.p. and 39·5 b.h.p., respectively, at 1600 r.p.m. The engines are four-cylinder, overhead valve units, with five bearings to crankshaft and camshaft, and are fitted with replaceable wet liners. The crankshaft is statically and dynamically balanced. Transmission is through a dry, single-plate, 11in clutch, and there are six forward gears, giving road speeds between 1·53 and 12·87 m.p.h., and two reverse gears. Heavy duty 9·00 by 36 six-ply industrial pneumatic tyres are fitted to the rear wheels, the front wheels being equipped with 6·00 by 19 pneumatics.

The implements to be shown on the Ford stand will include a mounted three-furrow disc plough, a Ford-Ransomes mounted semi-digger plough, and a mounted three-row ridger. This last implement is illustrated in Fig. 5. The ridger is arranged on the "Fordson" mounted tool-bar frame, which is 8ft long, holes placed at 1in intervals along the underside of the angle beams affording variable adjustment for the ridger beams. The three beams are of cast steel and each is rigidly attached to the tool bar by four bolts. The ridger bodies are staggered for maximum clearance, the under-beam clearance being 23in, and the centre body is independently adjustable for depth. The cast iron depth wheels of the tool-bar frame are screw-operated from the tractor seat and the simply constructed markers can be conveniently operated by a trip rope.

David Brown Tractors, Ltd.

The "Cropmaster" and "Trackmaster" tractors built by David Brown Tractors, Ltd., Meltham, Yorkshire, are to be shown by that firm at Earls Court. These tractors—both the diesel and t.v.o. engined versions—have been described in our columns on former occasions. The exhibits will include, however, the latest version of the "Cropmaster" diesel tractor. Whilst this tractor retains the principal design "points" of its predecessors, a more powerful engine has been installed. It is a four-cylinder, direct-injection unit, giving 23·5 drawbar horsepower. The engine is fitted with wet replaceable cylinder liners, silicon alloy pistons, and a monobloc cylinder head with overhead valves. The injection pump is equipped with a vacuum governor which controls over the entire speed range of 600 to 1800 r.p.m. To each of the four-cylinders a decompressor is fitted, and four-hole C.A.V. injector nozzles are standard equipment. With the new engine, the brake horsepower of the "Cropmaster" diesel is 31 at 1600 r.p.m., compared with 25 b.h.p. at 1400 r.p.m. in the earlier model; the new maximum belt horsepower is 29·5 at 1500 r.p.m., and the maximum sustained pull with ballast is 4500 lb. It is claimed that the tractor is capable of tackling heavier jobs at greater speed than its predecessor,

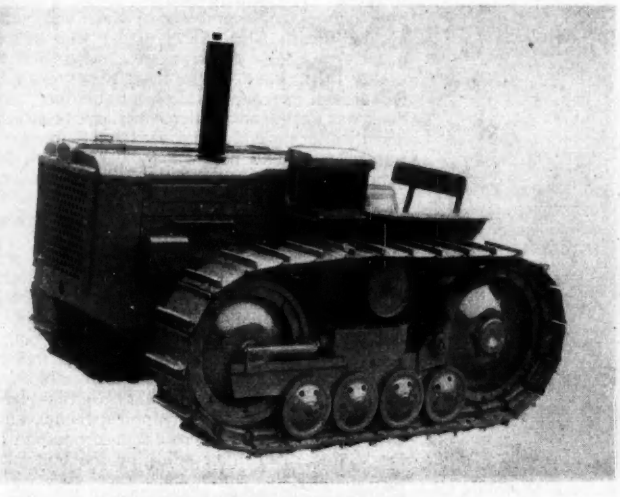


Fig. 4—Bristol "22" Tractor—Bristol Tractors

Fig. 5—Mounted Three-Row Ridger—Ford

Fig. 6—" Sapper " Rear Grader—David Brown

Fig. 7—" Horndraulic " Loader—David Brown

and can also perform light work with maximum economy.

A new implement which will be shown fitted to the " Cropmaster " diesel is the " Sapper " rear grader, illustrated in Fig. 6. The grader, which has been designed for attachment to the three-point linkage of all David Brown wheeled tractors, has a blade 6ft long and 1ft 6in high. The blade is raised and lowered by the hydraulic lift of the tractor, and is mounted on a sub-frame with a central pin. It can be raised approximately 2ft above ground level, can be tilted between 0 deg. and 25 deg. left and right, and has a 60 deg. to 75 deg. angle of cut.

Another exhibit is to be a modified version of the " Horndraulic " loader, a view of which is reproduced in Fig. 7. In this loader the radius arms have been widened, and are bolted to the tractor's rear wheel hubs and to a front mounting frame which the firm is now fitting to all the tractors in the " Cropmaster " series. The modification has resulted in a better distribution of the load between the tractor's rear axle and the sub-frame. The hydraulic lifting mechanism, which is controlled from the tractor seat, includes twin rams of large capacity and a gear pump. The maximum lift of the loader is now 11ft ; the boom has been redesigned for a drop below ground level to accommodate a bulldozer blade if required. Among the additional equipment which can be used with the loader, a " push-off stacker " is to be shown. It can be employed for hay sweeping, lifting and stacking, and is a hydraulically operated attachment with steel-tipped wooden tines. The stacker is 10ft wide and has a capacity of 1000 lb.

HARRY FERGUSON, LTD.

Three new products are to be included in the exhibits of Harry Ferguson, Ltd., Coventry, all of them being designed, of course, for operation with the Ferguson tractor. They are a hydraulically controlled buckrake, a mounted tandem disc harrow, and a low-volume spraying machine. The buckrake is of tubular construction, in the design of which the desirability of combining maximum strength with minimum weight has been kept in mind. The actual weight of the implement is 280 lb, and the claim is made that it can effectively handle a load of 750 lb. The linkage system is arranged to enable ground reaction against the tine tips to be transmitted as a forward thrust direct to the tractor's hydraulic system, thus preventing any digging-in and consequent wheel spin. A telescopic carrying link which is incorporated in the design relieves the hydraulic system of all load during the transport of the crop.

A photograph of the low-volume sprayer is reproduced in Fig. 8. The machine consists primarily of a 45-gallon steel tank which is lined with corrosion-resistant material, one centre and two side spray booms, and a gear pump driven through a universal shaft from the tractor power take-off. The sprayer is attached to the tractor by a three-point linkage and is held rigidly in position by a self-locking diagonal link. Both the outer spray booms are fitted with spring-loaded hinges which allow them to swing back and forward if an obstruction is met, and then return to their correct position. The outer booms can be raised independently by levers which are within easy reach of the tractor driver's seat, and each of the side boom control cocks is connected to one of these lifting levers. When a boom is raised above 45 deg. the cock shuts off all spray to it. Each outer section is able to spray up to a maximum of 45 deg. from the horizontal, and all sections of the boom can be adjusted while in the spraying position to give nozzle heights from 18in to 33in in 3in steps. There are three spray control cocks —a main cock and the two side boom control cocks. The main control cock has two positions, " spray " and " spray shut-off and anti-drip." When the cock is in the latter position, the tank is isolated from the pump and the suction is transferred to the booms and tubing so that all the liquid is drained back into the tank. The drive to the pump from the power take-off is taken through a rubber-jointed universal coupling which is kept in position on the power take-off shaft by a spring-loaded mechanism. The important question of filtration has been given special attention in designing the sprayer. There is a strainer filter in the main filling orifice of the tank, a main pressure filter between the pump and nozzles, and a filter in each of the nozzles. All of them can be dismantled quite easily for cleaning.

(To be continued)

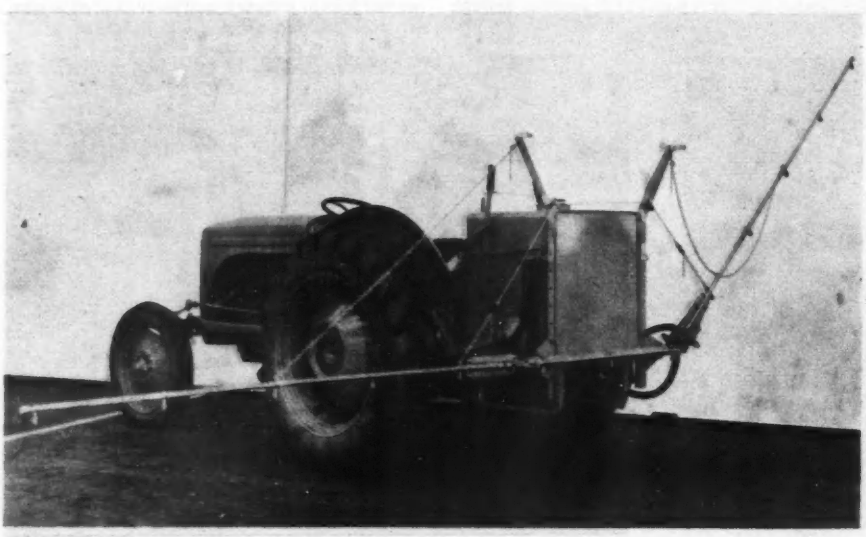


Fig. 8—Low-Volume Sprayer—Ferguson

Singapore Floating Dock

THE first section of the Singapore floating dock, measuring about 360ft in length and having a displacement of nearly 9000 tons, has been raised by the Boom Defence and Salvage Department of the Admiralty and is being prepared for towing to the United Kingdom for scrap. As soon as this work is completed it is intended to start raising the remaining part of the dock. The dock, which was towed to Singapore before the second world war, was sunk by the British when the port fell and subsequently raised by the Japanese. It was put to use by them and while they were repairing the armed merchant cruiser " Shiretoko," the dock was again sunk under American air attack. Shortly after the end of the war the " Shiretoko " was refloated and beached and last March the Admiralty salvage vessel " Salvictor," arrived to start salvage operations on the dock, being assisted by two " Bar " class vessels and a shore party. Extensive bomb damage made the wreck a major salvage problem and it was found expedient to cut the structure athwartships and raise the two portions separately. The work involved the under-water repair of leaking tanks and the blanking off of the piping system by divers, and the pressing of 1 million cubic feet of air into the tanks. Before blowing air into the tanks the buoyancy of each tank was estimated and shown upon a model, and, as a result, it was planned to raise one end of the section, then, after adjusting the buoyancy for stability, to raise the other end. The first section of the dock came up in accordance with the calculations.

A Railway Wheel Making Plant

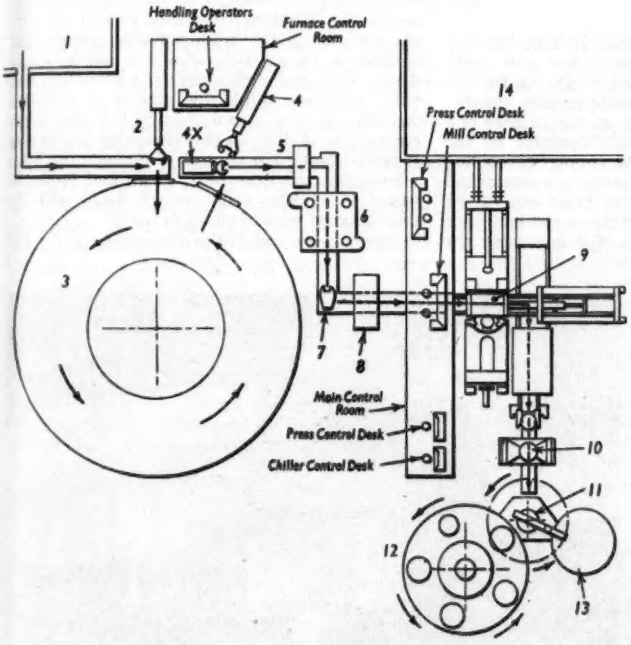
A new forge for the manufacture of rolled steel solid wheels and disc centres for railway carriages and wagons is now in production at the Trafford Park Works of Taylor Brothers and Co., Ltd. By using automatic sequence control for the various machine operating cycles, and grouping the main operator's controls, the plant is capable of a continuous output of sixty wheels an hour with little or no call for manual effort.

A NEW railway wheel forging and rolling plant which has been laid down at the Trafford Park, Manchester, works of Taylor Brothers and Co., Ltd., completes the first important stage in an extensive re-equipment and modernisation scheme designed to increase output and reduce manufacturing costs. The firm is a member of the English Steel Corporation, Ltd., group of companies, and the new plant, which has cost more than a million pounds, follows the installation of new plants at Sheffield for the improved production of railway springs, cast steel bogies and automatic couplers. As more than a half of the railway equipment made by the group is exported it will be appreciated that these schemes for increasing production are of considerable importance to this country's overseas trade.

The new plant produces disc centres and rolled steel solid wheels ranging from 24in to 50in diameter on tread at a continuous rate of sixty wheels an hour. The layout of the plant and the design of the equipment was completed by the firm's engineering department under the control of Mr. J. H. Ellis, the assistant chief engineer in charge of development, with Mr. E. Homer Kendall acting as consulting engineer. By the use of specially designed single-purpose plant and fully automatic ancillary equipment, a high rate of production has been achieved with the minimum amount of labour. At each manufacturing stage from the initial feeding of the furnace to the final placing of the finished wheel on the cooling lines all handling is effected by mechanical means, and the equipment operating cycles are automatically followed in correct sequence once they are initiated from the control desks. These control desks are arranged in two rooms sealed off from the plant floor, but having large windows through which all operations are clearly visible.

Before dealing in detail with the design and operation of the individual pieces of equipment, it would be well to give a general impression of the plant arrangement and work flow, with reference to the diagram we reproduce on this page.

The blocks of steel from which wheels are to be made are cut or broken from ingots in a separate shop at one end of the plant. The block weight is calculated from the finished wheel weight with appropriate allowances for furnace, punching and machining losses. From the ingot breaking shop the blocks are taken by a gravity roller conveyor to a furnace charger in the main forge building. This charger picks the blocks up one at a time and places them in radial rows across the hearth of a 69ft diameter rotary furnace. After heating, the blocks are removed in turn by a furnace discharging machine and placed on a transfer car. This car first carries the block through a hydraulic descaling machine and then on to an 8500-ton hydraulic forging press.



1. Ingot breaking and storage shop.
2. Furnace charging equipment.
3. Rotary hearth furnace.
4. Furnace discharging equipment.
4X. Block transfer bogie.
5. Hydraulic descaling stand.
6. 8500-ton forging press.
7. Press unloader.
8. 1000-ton punch press.
9. Wheel rolling mill.
10. 2000-ton dishing press.
11. Hydraulic jib crane.
12. Rim chilling machine.
13. Final lay-down station.
14. Motor and pump room.

Layout of Wheel Plant

After slabbing down between flattening tools in this press the bloom is transferred to forging tools mounted on sliding tables on the press bed and crosshead. With these tools and under increased pressure the slab is forged to finish the hubs, partially form the bore and prepare a rim section suitable for rolling. The complete forging is then transferred from the dies to a live roller table by an unloading unit and conveyed to a 1000-ton capacity upstroking punching press equipped with hub clamping dies. Its hub having been punched the wheel then passes on the roller table, through a tunnel beneath the main control room, to a rolling mill. In this mill the rim section is reduced in volume and rolled to the required contours with an accompanying increase of wheel diameter. The rolled wheel is removed from the mill by an unloading unit and placed on a transfer car, which carries it to a 2000-ton dishing press. With its rim clamped by suitably shaped dies, pressure is applied to the wheel hub and plate to impart the correct hub offset and plate contour. After dishing each wheel is stamped with identification numbers and transferred either to a five-station rim chilling machine or direct to a cooling bed.

Furnace Equipment

The furnace charging machine consists of a cable driven carriage mounted on a bridge, with the peel hoisting mechanism, together with the oil hydraulic equipment for the gripping motion mounted on this carriage. The machine is arranged to complete automatically a cycle of operations once it is initiated by the operator, after he has indexed the rotary hearth of the furnace. The cycle commences with the lifting of the furnace charging door and the tongs then grip the first block on the feed conveyor at a fixed distance from its base. As the peel structure is lifted the tongs rotate to bring the axis of the block into the vertical position and the base of the block to a fixed distance above the furnace hearth level. The carriage moves to the extreme forward position to set the first block of the charge at the innermost position on the furnace hearth. At the completion of forward travel mechanism automatically comes into effect to lower the block to the hearth, and this motion, in turn, releases the grips. At the end of the release stroke the carriage automatically moves back to its original position and the cycle is repeated as each successive bloom is charged. The forward travel of the carriage is sequence controlled from a multiple-cam limit switch to space the blooms across the width of the hearth. After the seventh or outside bloom has been charged the furnace door is closed and with the peel and tong head in their rest position, sprays of cooling water are played upon them. The carriage travel control has provision for variable radial spacing of the blocks on the furnace hearth and for the charging of any number up to a maximum of seven blocks.

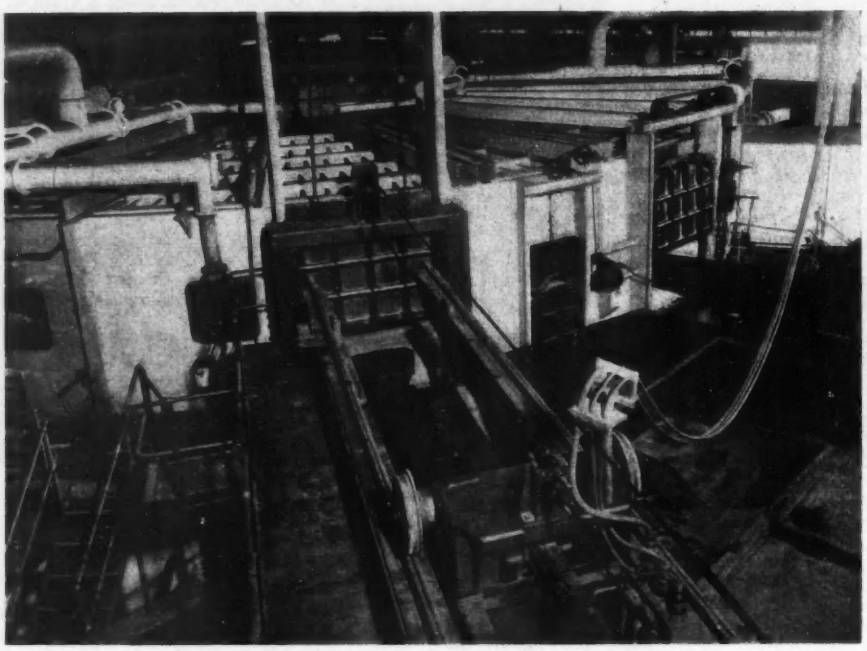
The rotary hearth furnace, which was built by the Salem Engineering Company, Ltd., and is shown in one of the illustrations overleaf, is stated to be the largest of its kind in this country. It has a rated heating capacity of 40 tons of steel an hour at a maximum temperature of 1280 deg. Cent. The diameter over the outer buckstays is 69ft, whilst the annular hearth is 15ft wide and has a mean diameter of 48ft 3in. The charging and discharging doors are set at an angle of 30 deg., there being two suspended baffle walls arranged between the doors and built radially across the furnace. The furnace has four firing zones and is fitted with thirty-nine steam atomising burners designed for heavy fuel oil burning. Preheated air for combustion is obtained by utilising part of the heat contained in the waste gases—two Newton Chambers needle metallic recuperators being used as heat exchangers. Preheated air is used in the heating zones and atmospheric cold air in the preheating and soaking zones. The hearth is driven at diametrically opposed points by a 27 h.p. motor coupled through a differential gear and line shafting arranged in the furnace foundation. A reduction worm gear driven by vee ropes at each end of the shafting has the pinion on its output extension shaft meshing with a rack fixed to the underside of the rotary hearth structure.

The hearth is carried on 108 wheels fitted with taper roller bearings and running on circular rails. The fifty-three rows of blocks which are heated in the furnace are arranged in the 330 deg. between the charging and discharging doors to give a total number of 371 blocks in the furnace at any one time. The rows of blocks are carried through the heating and soaking zones of the furnace by progressive indexing of the hearth at a rate corresponding to the output of the plant. At a production rate of sixty pieces per hour the heating time of the blocks is approximately 6¼ hours.

The flat, suspended arch furnace roof is formed of tongued and grooved interlocking blocks, and the furnace walls are carried on sand-seal dipper castings. The inner wall of tongued and grooved interlocking bricks forms a polygon of flat vertical panels, and a four-piece refractory burner is placed in the centre of each panel.

The furnace foundation is an open pit about 7ft deep designed to ensure adequate ventilation under the hearth and prevent overheating of the steel structure and wheel bearings. The inner buckstays are carried on piers, and steel beams which span the space between these piers and the outer foundation wall form the bottom ties of the furnace binding as well as providing a supporting means for the track rails.

At the end of the heating cycle blocks are removed from the furnace by a high bridge discharging machine of 1 ton capacity, which is generally similar in design to the charging machine. The photograph reproduced



Rotary Hearth Furnace, Charging and Discharging Machines

herewith shows the furnace with the discharging machine in the foreground and the charging machine in operation in the background. During the discharging operation travel of the carriage inwards to the predetermined billet position is controlled by a multiple-cam limit switch.

At the fully withdrawn position the tongs are aligned over the table of an air-operated ram which has a stroke of 30in. Operation of this ram is interlocked with the positioning of the discharger carriage in order to prevent the release of a block when the ram is not at the top of its stroke; at the same time the mechanism allows the operator to commence the discharging cycle before the ram table is raised. To commence the discharge of a row of blocks the carriage travels to the outermost hearth position with the peel lowered. Completion of travel initiates gripping of the first block in the tongs and this is followed by a hoisting of the peel, withdrawal to the ram table and lowering of the peel. If the table is raised the release of the tongs and subsequent lowering of the table take place automatically together with a closing of the furnace door. The operator then starts the transfer cycle of the block from the table to a transfer car for transport to the descaler and press, and the discharging machine can be restarted. After the furnace door has been rehoisted the discharger commences its inward travel and again completes its cycle by withdrawing and holding a second block over the table until it is automatically raised following the return of the transfer car to the furnace. The cycles are repeated until the innermost block in a radial row has been discharged.

A system of signal lamps on the control desk shows the operator at a glance how many blocks remain in a row to be charged and discharged at any time. The hearth is not indexed until a clear space is indicated at the discharging position. Complete sequence controls on the charging and discharging machines automatically reset for the next cycle of operations. A rotating dial mounted outside the control room and clearly visible to the operator is geared to the hearth and is used for maintaining continuous indications of the progress of the blocks through the furnace and of the operation of the hearth indexing limit switches.

The transfer car used to carry the hot block from the discharger table has a welded tubular body and is mounted on four flanged wheels. The front bulkhead of the body carries the grips for the block, and all of the car's operations are automatically controlled through a built-in hydraulic unit and switchgear.

The car travels on flat-bottom rails on a fabricated track structure 67ft long, of which the end farthest from the furnace is built into the hydraulic descaler. A bank of live rails along one side of the track supplies current for the pump motor and the sequence control circuits. An electrical contact switch at the furnace end of the track is automatically operated by the transfer car to control the supply of cooling water to the peel of the discharging machine. Similar track switches at the press end of the track are used for slowing down the car prior to it entering the descaler, for operating the descaler control valve and for finally stopping the car when the block is over the 8500-ton press slabbing die. Similar switches are used at the furnace end of the track for slowing down and stopping the car on its return journey to the furnace and for interlocking duties. Release of the blocks from the car grips, which is followed by the automatic return of the car to the furnace, is under the control of the operator of the 8500-ton press.

The hydraulic descaling machine has six water nozzles, each of 27·2 gallons per minute capacity mounted in an adjustable header pipe above the block and six similar nozzles in a fixed header pipe set 6in below the lower surface of the block. Canal water at a pressure of 1500 lb per square inch is used for descaling and the operation is fully automatic, the transfer car turning the water on and off on its forward travel to the forging press.

Immediately after its passage through the descaler the block is deposited on the table of the forging press, and the transfer car returns for its next load. The press, with the descaler on its right-hand side, can be seen in the second illustration on this page.

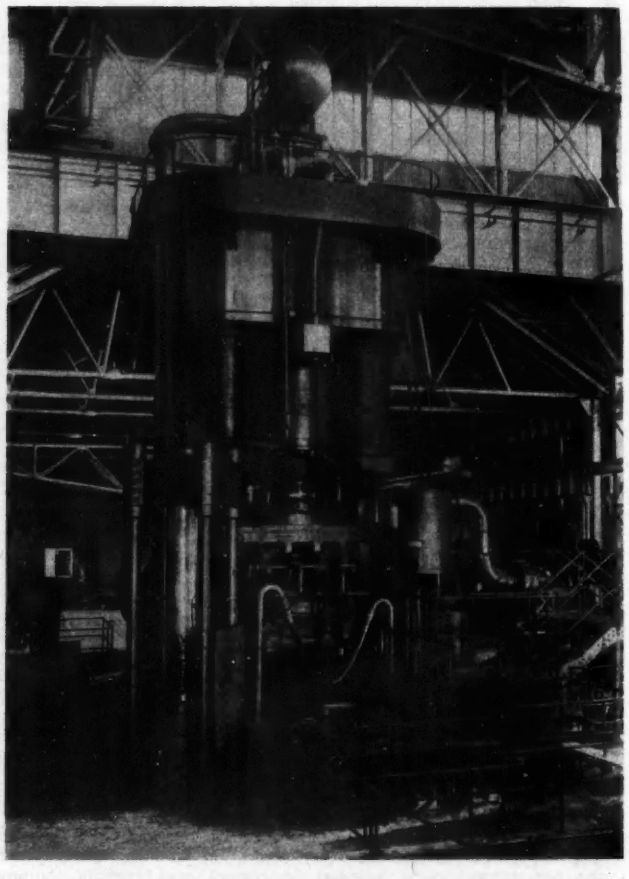
In this 8500-ton forging press the block is first slabbed down between flat dies to the required thickness and it is then gripped in centring arms and transferred to the lower forging die. The upper sliding table of the press is then moved to bring the top forging die under the centre line of the machine. This second forging operation is completed under intensified pressure and during this process the next block to be forged is placed on the slabbing die by the transfer car. The lower sliding table then moves back to bring the completed forging over the stripping ram and the following block under the press ready for slabbing.

At an intensified pressure of 5600 lb per square inch the maximum load on the press is 8500 tons and this load can be reduced on smaller forgings by lowering the pressure in the air-loaded accumulators which serve the machine. The press is fitted with four cylinders, having a diameter of 33¾in and a stroke of 36in. Between the sliding tables the "daylight" is 5ft 7in, the top and bottom tables having travels of 5ft and 9ft 6in respectively.

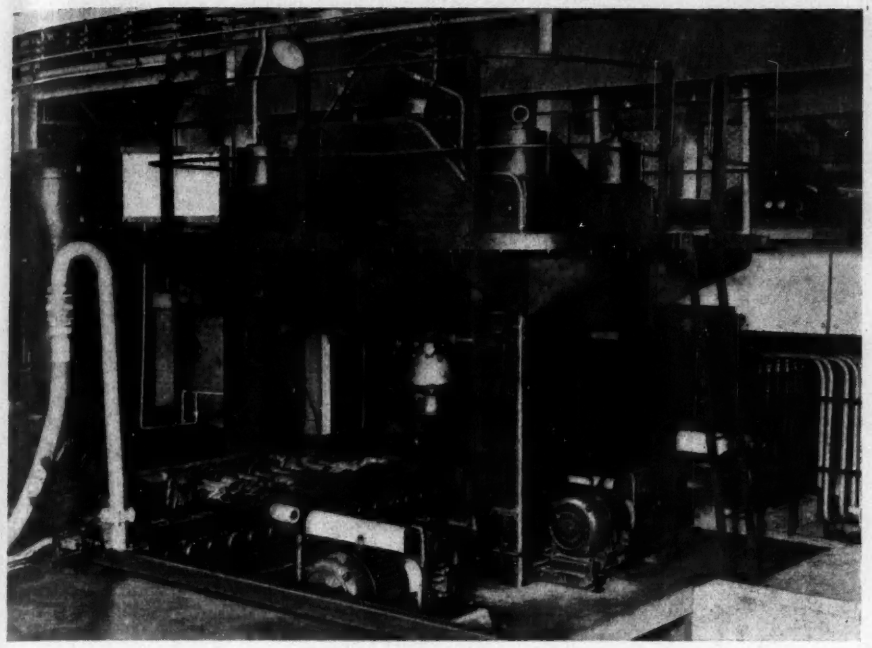
Cooling equipment for the top die is built into the moving guards on the lower sliding table and its water sprays are automatically operated by valves actuated by the table movement. Cooling of the lower dies is effected by spray rings attached to the crosshead and fed through flexible hoses.

All of the main hydraulic valves for this machine are arranged in accessible chambers in the foundations between the press and the control room. In the electro-hydraulic control gear of the press "V.S.G." auto-controlled pumps and solenoid-operated pilot valves are used to direct oil to servo cylinders mounted under the main valve spindles. With this system it has been possible to group conveniently all the press controls on a desk so that this stage of forging is placed under the control of a single operator who—protected from heat, steam and noise—is seated in a clean main control room with an unobstructed view of all operations.

When at the end of this operation the forging



8500-Ton Hydraulic Press



1000-Ton Punching Press

is lifted from the bottom die by the stripping ram, it is gripped, raised and slewed through 90 deg. by a special machine to bring it directly over a live roller table which runs through the punching press and on to the rolling mill. This press unloading unit is operated by the punching press operator seated alongside the 8500-ton press operator at a common control desk.

The roller table on to which the forging is deposited is divided into four sections each having a separate driving motor. No. 1 section serves as a receiving table from the press unloader ; No. 2 section is built into the punching press and mounted on the press column structure ; Nos. 3 and 4 table sections carry the blank from the punching press under the main control room into position for charging into the mill. The first three sections of table run continuously, whilst the fourth table is slowed down and stopped by photo-cell equipment at the mill end and is restarted automatically by operation of the mill loading mechanism.

The upstroking punching press has twin 26in diameter rams and with double-acting pull-back cylinders. It has a rated capacity of 1000 tons and a punching stroke of 9½in at a speed of 3in per second. A 100 tons capacity boss clamping cylinder is mounted in the press crown around a rigid punch stem. The forging, on arrival in the punching press, is centred by an adjustable stop mechanism and lifted off the live rollers by the lower boss clamping die. Continued upward movement of the crosshead first clamps the boss and presses the hub against the rigid punch. When the punch has pierced the boss the crosshead is stopped by a limit switch and the forging is lowered on to the live rollers. In the meantime, the centring stop is removed and the forging is allowed to proceed to the mill. The control gear of the piercing press is similar to that used on the 8500-ton forging press.

The wheel rolling mill loading unit is mounted under the main control room, its main supporting frame being pivoted at the mill end and suspended at the other end from a curved track. This arrangement facilitates the alignment of the machine in relation to the mill rolls. A simple carriage actuated by a hydraulic cylinder carries a self-centring grip mechanism which is rotated to enable the grips to clear the wheel forging. The travel stroke is arranged to take the forging from the end of the roller table to the centre line of the mill where it is deposited on forks attached to the roll carriages. This mill, which is of Taylor-Kendall design, is illustrated in one of the photographs reproduced on this page.

The forged rim section is reduced in area in the mill and formed to the required shape by means of driven edging rolls which bear on the front and back faces and on the inside contours of the rim, and by the load on two pressure rolls which bear on the tread and form the flange. The mill has also a driven main roll mounted in an adjustable carriage, and two guide rolls mounted on a separate carriage, but sliding on the same ways as the main carriage. The hydraulic pistons operating the guide roll carriages are attached to the main roll carriage to give movements relative to that carriage. By this mounting arrangement of the guide rolls they can be retracted behind the main roll to facilitate loading and unloading of the mill. Pressure regulation on the carriages during rolling controls the formation of the section and the rate of expansion of the wheel diameter. Indicating equipment is built into the mill to show the inside diameter of the rim, and mill setting scales are mounted on the side of the main stand for rapid setting up to suit varying rim width and roll diameters.

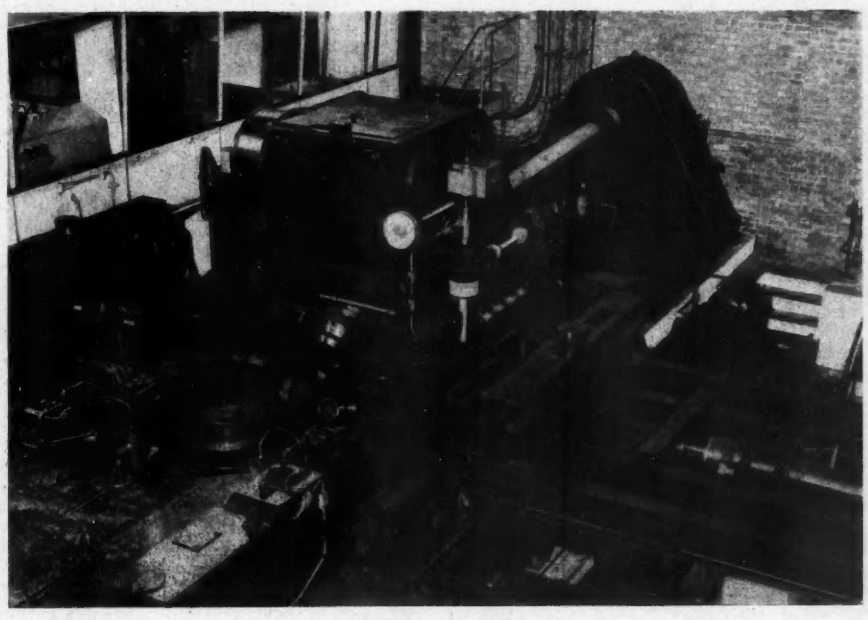
The top and bottom edging rolls are each driven by a 400 h.p. d.c. motor having a speed range of 690 to 860 r.p.m., and these motors during rolling are coupled in series across a 480V generator. The main roll, which is the only other driven roll, is carried on a tapered extension of a vertical shaft and is driven through intermediate shafts and gearing by a 150 h.p. mill motor having a speed range of 460 to 1150 r.p.m. All driven roll speeds are independently variable and the overall mill speed is also adjustable to maintain preset roll speed ratios modified to suit the various roll diameters.

The primary gearbox, edging roll quills and main roll gearbox of the mill are fed with lubricating oil from a De Laval circulating unit installed in the motor room basement. This unit has duplicate gear pumps, a motor-driven filter, steam heating coils and oil cooler. It has automatic control equipment to bring the second pump into operation in the event of loss of pressure and is provided with audible warnings for excessive pressure. The mill motor controls are interlocked with the lubrication system to prevent the starting of the mill until the lubrication system is in operation.

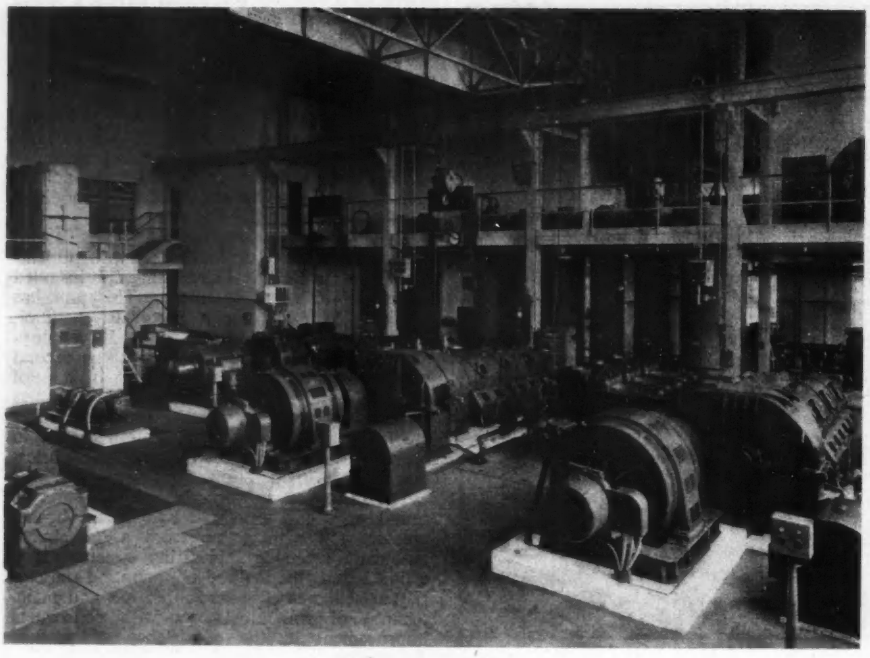
The three roll carriages of the mill slide on round ways and are fitted wth bronze bushes pressure fed with grease from a "Trabon" automatic reversing lubricating system. It is claimed that this method of mounting the carriages facilitates effective lubrication and maintenance of roll alignments with consequent improvement in the consistency of product dimensions.

Both of the edging roll shafts are mounted in quill castings which are mounted on pivot shafts having an eccentric centre portion for quill adjustment, and rocker bars at the roll end of the quills are connected through adjustable pitman arms to the screw-down crankshafts. The crankshaft for the lower roll is connected through a worm gear to a 5 h.p. mill motor forming a drive for retraction of the roll. The upper quill is similarly connected to a 20 h.p. d.c. mill motor of 450/1200 r.p.m., which is coupled to a Metadyne set having a 35 h.p. driving motor, a 0/17kW, 0/230V generator, a 5kW, 250V exciter, and a 600W, 150V Metadyne exciter. Controls are provided to give "instantaneous" edging, which produces a parallel wheel web, or a "continuous" edging to produce a tapered web by the use of an electronic ratio controller which is coupled to the wheel growth dial. A separate controller is provided for manual adjustment of the top screw-down motor.

Each wheel, on completion of the rolling, is transferred to a flat-topped car on which it is taken and set in the bottom die of the dishing press. The lower sliding table of the press carries



Wheel Rolling Mill



Motor Room

the die under the crosshead ready for the dishing operation which changes the web of the wheel from a flat disc to a cone shape and sets the boss offsets.

This press has a two-piece top die, mounted in a holder on the crosshead, and on its bottom sliding table, which has a stroke of 6ft, are mounted the bottom dishing die and a stripping stool. It has a rated capacity of 2000 tons at an accumulator pressure of 2200 lb per square inch intensified to 6000 lb per square inch on a single ram 31½in diameter by 2ft 7in stroke. The control system of this press is generally similar to that used on the 8500-ton press.

Adjacent to the dishing press is a 1-ton hydraulic jib crane having a guided hoist in the form of a rigid box section column sliding vertically in guides at the end of the jib arm. On the bottom of this column is a set of automatic tongs which are adjustable to suit varying wheel diameters. The crane is so placed that it can be slewed to bring its automatic tongs directly over the dishing press stripping stool, an adjacent chiller loading station or a final lay-down station, which are set at 120 deg. intervals around the 14ft diameter circle covered by the jib.

Before transfer from the dishing press stool each wheel is hot stamped with the cast number of the steel by stamps mounted in the jaws of a hydraulically operated toggle mechanism mounted in a carriage slung under the jib crane structure and traversed by a pneumatic cylinder.

The rim chilling machine has five chilling stations mounted on an electrically driven turntable 14ft diameter. At each chilling station is a set of three tapered rolls one of which is driven by an electric motor mounted inside the turntable hood. Box section spray rings are mounted on the roll housings and coupled to a pump located inside the turntable hood through a solenoid-operated valve. This pump, rotating with the table structure, draws water from an annular tank located around the vertical post which carries the weight of the whole machine. At the centre of each chilling station is a set of loading forks under which is mounted a live roller centre. At the point of intersection of the spray ring pitch line and the jib crane radius a fixed cam is arranged to lift the forks above the level of the live rollers in readiness to receive the wheel from the jib crane. After the wheel has been deposited on to the forks the main turntable is indexed one-fifth of a revolution, lowering the forks and leaving the wheel on the rotating rollers. The water spray valve of that station is automatically switched on together with the spray timing device which holds the spray valve open irrespective of further movement of the station. As the first station is carried away from the loading point the fifth station goes into the loading position and the wheel it carries is lifted from the live rolls by forks ready for transfer by the crane to the final lay-down position.

The final lay-down station consists of a simple turntable carrying three stacking pegs. These pegs are designed to receive five completed wheels and have their upper ends shaped to suit a set of automatic tongs fitted to an overhead crane used for removal of the completed stacks of wheels to the cooling beds.

Motor Room—Hydraulic Plant

The main pumps and accumulators for the press hydraulics, which are designed to operate up to a maximum working pressure of 2200 lb per square inch, are arranged to form two independent systems with separate control gear. The large system comprises five 68 cubic feet capacity strip wound air vessels and one 68 cubic feet capacity strip wound water vessel. The small system comprises two 68 cubic feet strip wound air vessels and one 25 cubic feet solid forged water vessel. The ratio of air to water volume is such that a pressure drop of 10 per cent is allowed over the normal operating levels. A three-stage Hamworthy air compressor of 18 cubic feet per minute capacity is used for charging the air vessels. The water and air vessels are connected to mercury level control pots of Vickers-Armstrongs design for control of the pumps and accumulator stop valves. The pumps are unloaded by lifting the suction valves at predetermined water level and contacts in the mercury pots shut down the pumps at extra high level to avoid overfilling. Should the pumps fail to meet demands on the systems, further contacts are arranged to come into effect to close the accumulator auto stop valves and isolate the water vessels from the press supply lines.

The large accumulator system is fed by two three-throw Vickers-Armstrongs pumps, each having a capacity of 400 g.p.m. at 2200 lb per square inch. Each pump is driven through single-reduction, double helical gears by a Metropolitan-Vickers 6600V slipring motor of 750 b.h.p. at 740 r.p.m.

The small accumulator system is fed by a Davy three-throw pump of 160 g.p.m. capacity at 2200 lb per square inch. The pump is driven at 150 r.p.m. through a single-reduction, double-helical gear by a Metropolitan-Vickers 6600V slip-ring motor developing 275 h.p. at 740 r.p.m.

It is possible by means of the independent accumulator systems to operate the 8500-ton press at lower pressures than the punching and dishing presses and thus to consume less power in the forging of smaller products. The accumulators can be connected together to operate as a combined system by equalising the air pressures and opening a stop valve in the water lines. The pumps and accumulators are housed in the motor room shown in the illustration on this page, and the valves are arranged under the vessels in a basement which extends into the main pipe subways and the press foundations.

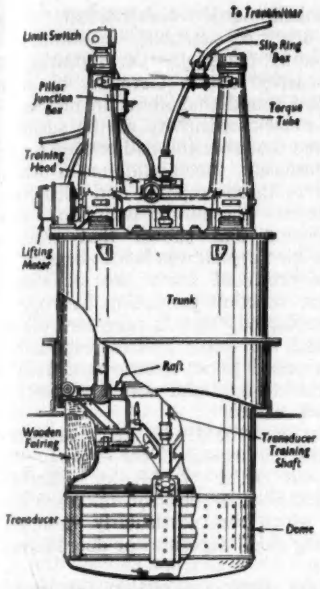
The Echo Whale Finder

This year several whalecatchers have sailed for the annual whaling expedition equipped with an Echo Whale Finder which has been developed over a period of years by Kelvin and Hughes, Ltd. With the aid of this fitting, which transmits ultrasonic sound impulses through the water, the time taken in hunting the whale can be decreased and the chances of a successful kill increased so that operating costs may be reduced.

FROM the days of the Dundee whaler there has evolved the present-day whaling fleet, with the floating factory ship acting as the parent vessel to a number of attendant whalecatchers, working for a limited season, the length of which is internationally controlled. The success of the yearly expedition is governed by the proportion caught of the total number of whales which may be taken by all the whaling expeditions. Much depends upon the skill and experience of the harpoon gunner in firing the harpoon gun and in bringing the ship within firing range. The Blue and Fin whales, which are species usually taken to-day, usually surface to "blow" every two or three minutes and periodically "sound" for as long as twenty minutes. When under water the whale may swim in any direction so that the gunner has only his judgment to rely upon to decide which course has been taken by the whale. Inevitably with nothing tangible to act upon as a guide, mistakes are made and several attempts may be required before a kill is effected, and since the maximum speed of a whalecatcher is almost the same as that of a whale, then many hours may elapse before coming within firing range.

Any aid which reduces the time occupied in hunting increases the possible number of kills, thus reducing operating costs and increasing the total value of the season's fishing. It is to assist in the first part of the operation that the "Echo Whale Finder" has been designed, and by using this equipment the gunner, once contact has been made, is given continuous information of the course followed by the whale and thus is able to close for a shot in the minimum of time. The equipment which is analagous to Radar, is not intended to provide a first warning of the presence of a whale, since it is usually spotted from the crow's nest when at a distance in excess of the range of the "Echo Whale Finder." This generally comes into operation when the ship has approached within a mile or so of the whale. However, in conditions of restricted visibility the apparatus may give the first warning of the presence of a whale which would be missed otherwise.

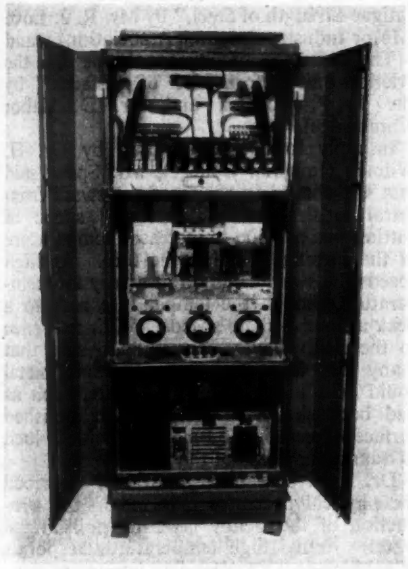
As a result of several years of research and development, Kelvin and Hughes, Ltd., has developed the "Echo Whale Finder" and the equipment has been tested under operational conditions for three whaling seasons in co-operation with Chr. Salvesen and Co. After these proving trials the equipment is now in general production and eleven whalecatchers of the fleet of Chr. Salvesen and Co. have been



Transducer Hoist/Train System

fitted out with the gear and the vessels will be attached to the "Southern Venturer" and "Southern Harvester" expeditions during the next whaling season.

The equipment consists of four main parts—an electro-acoustic transducer, complete with hoist and train system, which we illustrate; a pulse generator and receiver; a motor alternator and control cabinet and a console unit. The set operates on 110V d.c. and the power consumption is about 2¼kW continuously while transmitting, 2kW when raising and lowering the dome, the maximum demand being approximately 4¼kW. A sound transparent stainless steel dome houses the transducer, which emits ultrasonic sound pulses in a narrow horizontal beam which can be trained through 360 deg of azimuth; the echoes from the whale are amplified and indicated aurally and visually.



Transmitter Panels

Two alternative frequencies are used, the lower for long and medium ranges and the higher for short ranges, while alternative pulse lengths and vertical beam widths are provided to aid in keeping contact to within firing range, which is about 20 yards. Five scale ranges are provided, the maximum being 2000 yards.

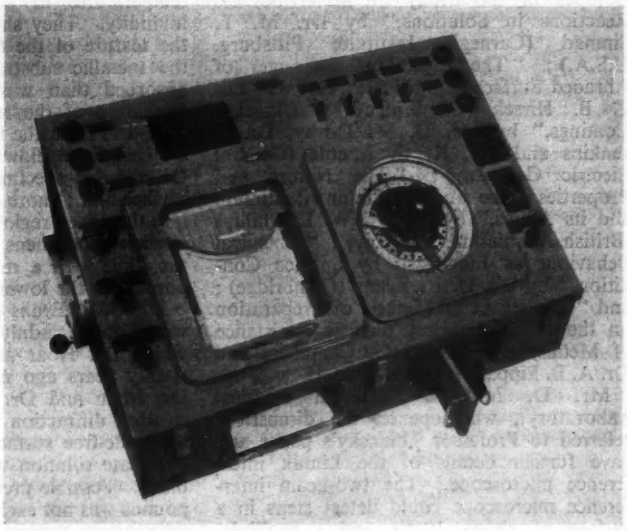
With the exception of the console unit all the equipment is fitted in the compartment, located forward just above the keel, housing the directing gear trunk. The console unit is mounted at the after end of the bridge, at a point giving a good all-round view, and housed in a suitable hut.

The whale finding equipment has been designed to keep maintenance requirements to a minimum and, to meet the arduous conditions, the electronic units are shock-mounted and lubricants suitable for low temperatures used.

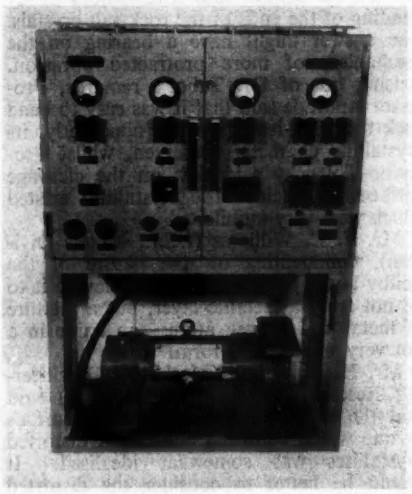
The transducer has two faces subject to magnetostriction, one face for 25 kc/s and the other 14 kc/s; it is 15in wide and is made up of horizontal strip elements which can be switched so as to provide the various vertical beam angles. These are 13 degrees, 36 degrees and 50 degrees for the narrow medium and deep beams for 14 kc/s, the corresponding angles for 25 kc/s being 14 degrees, 31 degrees and 48 degrees, respectively, with the axis of the deep vertical beam being tilted 22½ degrees below the horizontal. The horizontal beam for the respective cycles is 15 degrees and 8 degrees. A hollow training shaft carries the transducer, which can be trained through 360 degrees in 15 seconds; around it is arranged a streamlined casing consisting of top and bottom castings and a number of horizontal frames covered by a thin sound-transparent shell. The dome is secured to the raft, which is fitted in a watertight trunk open to the sea at the bottom and mounted on a seating built into the ship's hull on the centre-line forward. A 2 h.p. d.c. motor drives the screws which raise and lower the raft and by this means the dome can be lowered in 45 seconds and housed in 70 seconds. A wooden fairing secured to the raft and filling in the neck of the dome reduces the risk of fouling the harpoon line when the dome is down.

A 2kVA machine driven from the ship's d.c. supply provides 230V, 50 c/s a.c. to operate the pulse generator and receiver. On the receiver rack are mounted the receiver amplifier and supply panels, the amplifier gain being reverberation controlled and initial suppression is provided, while the h.f. signal is rectified for marking a chemical paper recorder and heterodyned to 1000 c/s for aural detection. Also mounted on the rack is a pack bias panel, which provides a steady d.c. bias to the transducer, the direct current being obtained from the motor alternator via a step-down transformer and rectifier housed in the control cabinet. The send/receive panel, mounted on the transmitter rack, includes rapid changeover switching to connect the transducer to the transmitter or receiver, while high-speed relays determine the pulse length. Mounted on the same rack are the transmitter and e.h.t. supply panels (seen in our photograph) which include a master oscillator and power amplifier combination with low power keying on the buffer stage and the means for changing frequency by remote control. In the control cabinet, a photograph of which we reproduce herewith, are the circuits controlling transducer training, dome housing and bias supply, together with an automatic starter and carbon pile regulator for use with the alternator.

In the console unit, which we illustrate, are grouped the training control, range recorder and operating switches. By means of the training control the transducer is trained manually by means of a servo system and its bearing is indicated by a repeater pointer. A gyro repeater automatically stabilises the transducer in azimuth to the last bearing set by the operator, so that once contact has been established changes of course do not throw the beam off the target. The range recorder is of chemical pattern using potassium iodide paper, and is fitted with three revolving pens to eliminate delay between the traces. A governed d.c. motor provides the time base for a range scale and a five-speed gearbox gives five alternative range scales of 250, 500, 1000, 1500 and 2000 yards.



Console Unit



Control Cabinet

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

DIMENSIONS OF FOUNDRY MOULDING BOXES

No. 1889 : 1952. This standard was prepared at the request of the Institute of British Foundrymen, its object being to provide a standard range of moulding boxes and their essential components for the foundry industry in order to increase interchangeability both to reduce the excessive number of types at present in use and to aid designing, work planning and costing. It is realised that special-purpose boxes will, of necessity, still be required, but it is considered that in the majority of instances the range of sizes specified will satisfy the major requirements of the industry.

The standard specifies dimensions of two-pin square, rectangular or round box parts, designed for loose pins, of sizes ranging from 12in by 12in by 3in to 72in by 72in by 24in, with pin diameters ranging from ⅜in to 1¼in and distances between pin centres ranging from 15in to 77in. It specifies also dimensions of lugs and bushes, which may be single or double. Price 2s. 6d.

Properties of Metallic Surfaces

INSTITUTE OF METALS

A SYMPOSIUM, organised by the Institute of Metals, on "Properties of Metallic Surfaces" was held at the Royal Institution on November 19, 1952. After Dr. C. J. Smithells (president) had welcomed visitors from kindred societies and from abroad, the chair was taken by Professor A. G. Quarrell (chairman of the Metal Physics Committee), and the first group of papers* was introduced by Professor A. H. Cottrell. These were :—"Specialised Microscopic Techniques in Metallurgy," by Professor S. Tolansky (London); "Radioisotopes in the Study of Metal Surface Reactions in Solutions," by Dr. M. T. Simnad (Carnegie Institute, Pittsburg, U.S.A.); "The Crystalline Character of Abraded Surfaces," by Dr. P. Gay and Dr. P. B. Hirsch (Cambridge); "Diffusion Coatings," by Mr. D. M. Dovey, Dr. I. Jenkins and Mr. K. C. Randle (General Electric Company); "The Nature and Properties of the Anodic Film on Aluminium and its Alloys," by Mr. H. W. L. Phillips (British Aluminium Company); "Chemical Behaviour as Influenced by Surfaee Condition," by Dr. U. R. Evans (Cambridge); and "The Effect of Method of Preparation on the High-Frequency Surface Resistance of Metals," by Dr. R. G. Chambers and Dr. A. B. Pippard (Cambridge).

Mr. D. McLean (National Physical Laboratory), who opened the discussion, referred to Professor Tolansky's paper and gave further details of the Linnik interference microscope. The two-beam interference microscope could detect steps in a surface of about 10^{-6}in and a multiple-beam instrument was about ten times as sensitive.

Professor Tolansky said that Bausch and Lomb had produced a simple adapter to screw on to an ordinary microscope to convert it into a Linnik interferometer. He also described a very cheap and efficient technique which consisted of putting a drop of Canada Balsam, in solution, on the surface of the specimen. The Canada Balsam dried and formed a film, taking up the contour of the structure, and with this thin film very good interference fringes were obtained.

Dr. F. Wormwell (Chemical Research Laboratory, Teddington), referring to the importance of surface roughness factors in corrosion, said that when two specimens, one with an ordinary machine-turned surface and the other prepared by fine emery, were connected externally in a half normal sodium chloride solution, the rougher surface was corroded and the smoother surface was protected for at least fifty days, though there might be an increase in the total corrosion of the system. When specimens were rotated at high speed in sodium chloride solution the corrosion rate was higher on grit-blasted specimens than on those which had been emeried. In circumstances in which passivity was produced by rapid movement, grit-blasted specimens usually showed some corrosion. In general, corrosion of a machined surface tended to begin on the crests of the turning marks and not in the troughs. Referring to the mechanism of inhibition, Dr. Wormwell said that, in agreement with Dr. Simnad, they had found that chromium in some form was present on the surface after immersion in chromate solution, and that as rusting occurred there was a high concentration of chromium in the rust. Rust, apart from the metal surface, would take up chromate. He thought that, while Dr. Simnad's results were consistent with the theory of Hoar and Evans, they did not conclusively support it.

Later in the discussion Dr. W. H. J. Vernon (Chemical Research Laboratory, Teddington) showed a number of slides indicating the effect of surface condition (abraded, chemically etched or vacuum annealed) on the oxidation film formed on metals at raised temperatures in atmospheres of different humidity. They showed the importance of the texture of the oxide film in relation to the metallic substrate. More oxygen was absorbed than was accounted for by the formation of the removable film. Oxygen passed in from the film-air interface to form a mixed zone below the surface of the metal. On abraded specimens there was a thinner surface film; more of the oxygen had passed into the mixed region. On etched or vacuum annealed specimens the oxide was mainly in the film, with a minimum of oxide incorporated in the lower layer.

Dr. U. R. Evans (Cambridge) said that he would not be unduly worried if the suggestion which Dr. Hoar and he had put forward twenty years ago might need modification. Dr. Main and Dr. Mentor had shown by electron diffraction that the film formed on an oxide-free surface of iron exposed to a chromate solution was chiefly gamma ferric oxide. Possible presence of chromium compounds was not excluded, but it was possible that better protection might be obtained when the protective film was simply iron oxide. Mr. D. E. Davies, working on the oxidation of iron at about the same temperatures as those Dr. Vernon had referred to, had found that abraded iron behaved very differently from a smooth surface, in the manner described by Dr. Vernon.

Earlier in the discussion, Dr. Tabor (Cambridge), commenting on the paper by Gay and Hirsch, described an experiment in which a rock salt slider was made to slide just once over the cleavage face of a rock salt crystal. The track produced consisted of a large number of blocks about 10,000 Å square, tilted at about 10 deg. to the surface. This might be accounted for either by fragmentation of the surface into little blocks or by bending of the ends of the rock salt crystals. The answer might have a bearing on the mechanism of more protracted abrasion. Arising out of Dr. Tabor's remarks, Professor Andrade said that it was easy to bend rock salt and leave it with, apparently, its crystalline character preserved, whilst Professor Tolansky said that on the cleavage surfaces of calcide little crystallites existed which were very mobile.

Mr. E. C. Williams (I.C.I., Metals Division), commenting on the nature of the Beilby layer, gave reasons for believing it to be not truly a metallic layer, but a mixture of metal and oxygen atoms—an oxide in a not very well-defined form.

Mr. H. R. Wright (Mechanical Engineering Research Organisation, D.I.S.R.) said that the conception of the abraded surface as one which consisted entirely of distorted crystallites was somewhat idealised. It would be better to consider the distorted layers as composed of a mixture of adsorbed and chemisorbed gases, oxides, probably of non-stoichiometric composition, together with distorted metallic crystallites and amorphous material. On repeating some work carried out in Germany by Kramer, they had found that abrasion increased the photo-electric sensitivity of the surface. It appeared that abrasion had created a number of composite metal-oxide-metal cathodes similar to those prepared and used for low-temperature thermionic emission. Parallel experiments had shown that whereas a cleaved zinc crystal was inert, abrasion of the surface produced active sites at which the cathodic reaction producing hydrogen peroxide occurred. It was suggested that these sites and the active centres responsible for the enhanced photo-electric sensitivity were identical in origin and were a property of an abraded surface.

Other contributors to the discussion dealt with different aspects of the subject. Among them was Dr. J. W. Mentor (Cambridge), who described an electron microscope technique which was particularly valuable for revealing small asperities or depressions in a surface.

At the afternoon session the chair was taken by Dr. D. G. Sopwith (Director of Mechanical Engineering Research, D.S.I.R.) and the following papers were introduced by Mr. D. A. Oliver :—"The Influence of Machining and Grinding Methods on the Mechanical and Physical Condition of Metal Surfaces," by Messrs. P. Spear, I. R. Robinson and K. J. B. Wolfe (B.S.A. Group Machinability Laboratory, Birmingham); "The Effect of Lubrication and Nature of Superficial Layer After Prolonged Periods of Running," by Dr. F. T. Barwell (Mechanical Engineering Research Organisation, D.S.I.R.); "The Effect of Surface Conditions on the Mechanical Properties of Metals, Mainly Single Crystals," by Professor E. N. da C. Andrade (London); "The Effect of Surface Condition on the Strength of Brittle Materials" by Professor C. Gurney (Cardiff); "The Influence of Surface Condition on the Fatigue Strength of Steel," by Mr. R. J. Love (Motor Industry Research Association); and "The Influence of Surface Films on the Friction and Deformation of Surfaces," by Dr. F. P. Bowden and Dr. D. Tabor (Cambridge).

In reply to questions raised by Dr. H. Wilman (Imperial College), Mr. Spear said that the change in shape of the swarf from spiral to straight with increased speed of cutting was not due to increased temperature of the turning as it left the tool. At high speeds the swarf came off at a very low temperature, though the temperature rose to a peak at intermediate speeds. With reference to the Beilby layer, Mr. Wilman said that many people were convinced that metal could exist in an amorphous state, such as had been shown to exist on the polished surface of certain non-metallic oxides, such as quartz and some of the gem stones.

Dr. F. P. Bowden (Cambridge) described the physical processes involved in the production of the Beilby layer by polishing a metal. Actual high temperatures at points of rubbing contact played an important part. There might be increased rate of oxidation, and the softened material would have stirred into it oxide and fragments of polishing material. Oxide particles could inhibit the growth of crystals in the Beilby layer, which, however, might be very different on different metals. Whether it was called amorphous or micro-crystalline seemed to be entirely a matter of terminology.

Professor B. Lunn (Copenhagen) discussed problems of a shaft running in a bearing, and particularly the formation of protective surface layers by reaction with the lubricant.

* A summary of the contents of the papers presented at this symposium was given in THE ENGINEER, November 28th, page 724.

At the moment of starting, when the shaft had metallic contact with the bearing metal, the properties of the metal were of importance ; but, when the shaft started to rotate, the shaft and bearing were separated by an oil film, though there were casual contacts even when the bearing was running hydrodynamically, and in these circumstances the boundary layer on the bearing metal and the shaft was of importance. Dr. Barwell had stated that the object was to produce a film of relatively low shear strength and so facilitate sliding. He would say that the function of the film was to prevent wear due to metallic contact. He described tests for the interaction between bearing metals and lubricants. Processes in which the lubricant, the bearing metal and the atmosphere take part contribute to the formation of the film. The action of the bearing metal was catalytically to oxidise the lubricant to form a soap film, which was the best possible protection against metallic wear. Dr. Barwell, commenting on Professor Lunn's contribution, said that work done in the D.S.I.R. laboratory with various kinds of white metal, using both compounded and plain mineral oil lubricants, had strongly supported the views expressed by Professor Lunn, and had shown that the boundary properties were almost entirely due to the reaction between the lubricating oil and the white metal. He had only one point of disagreement with Professor Lunn, in that he believed that a well-designed, well-engineered bearing would operate for most of its life as a purely hydrodynamic bearing, without contact.

Ing. R. Cazaud (St. Germain-en-Laye), referring to Mr. Love's paper on fatigue, said that, though inclusions were frequently the origin of fatigue failures, in a nitrided specimen free from inclusions a crack, not reaching the surface owing to the stress distribution, might form beneath the nitrided case. Mr. Love, in reply, said that where subsurface failures were found in engineering components, inclusions were nearly always responsible for the start of fracture. Monsieur Cazaud's second point was that Mr. Love had quoted one of his results showing that chromium plating had given increased endurance in fatigue. He wished to correct that. In all later work he had found a reduction of endurance limit for different steels, varying from 15 to 40 per cent.

Dr. G. Salomom (Delft) said that he represented the T.N.O., which was the equivalent in Holland of the D.S.I.R. As one interested in features of fracture phenomena common to different materials, he wished to comment on Professor Gurney's paper. Professor Gurney had assumed that glass behaved as an ideally brittle continuous medium ; but the phenomena of delayed fracture and dynamic fatigue observed for glass were very similar to the behaviour of rubber and plastics, brittle or non-brittle, and under certain conditions even of metals. What was observed for plastics and glass and rubber in the order of seconds was observed under certain conditions in metals at 10^{-8} or 10^{-4} second. He suggested that the essential similarity between glass and metals was that the fatigue phenomena were determined by the same type of rate reaction, which was the localised plastic flowing. Professor C. Gurney, in the course of his reply, said that there was a considerable difference between the mechanism of fatigue in metals and the mechanism of cyclic failure of glass, because metals contained glide planes, and the fatigue of a metal was associated with plastic flow on glide planes, whereas a well-made piece of glass was one homogeneous piece of material.

Dr. T. P. Hoar (Cambridge) referred to the valuable work of Professor Andrade on the effect of oxide films on the mechanical properties of metals ; but he was sorry to see that silver was used as an example of the effect being a large one, because he thought that silver, heated in air, did not form an oxide film, but rather that silver oxide, heated in air, would decompose to give silver and oxygen. He based this view on the theoretical ground that free energy became positive at about 200 deg. Cent. and above that temperature the oxide would be expected to decompose rather than to form on the metal ; and also on the results of practical experiment. A drop of mercury, applied to a clean metal surface, would almost immediately wet it, but if a passive oxide film were present there was no wetting. When pure silver was heated to 300 deg. Cent or above and mercury dropped on to the surface, the mercury wetted the metal at once, showing that there was no oxide film present. Professor Andrade, in reply, said that the figures quoted were for silver oxide in bulk, and things might be different for oxide on the surface of a single crystal. He did not press for oxide, but was fairly certain that a surface film of some sort was present.

Dr. G. W. Rowe (Cambridge) described some further work on the friction of metals. In an experiment with clean copper in a vacuum, direct evidence was obtained that a fatty acid by itself was not adequate to lubricate the surface. It prevented seizure, but friction did not fall to the atmospheric value unless oxygen and water vapour were admitted. This appeared to be direct confirmation of Dr. Barwell's remarks about the formation of a soap.

Mr. N. I. Bond-Williams (Aston Chain and Hook Company, Ltd., Birmingham) referred to the importance of an oxide film in reducing friction in wire drawing. It was, of course, important to reduce the amount of oxide on the surface, particularly on a wire, but too complete a removal of oxide reduced the life of wire-drawing dies.

Mr. J. G. Wistreich (B.I.S.R.A., Sheffield) confirmed the importance of oxide in reducing friction, and quoted an example bearing out the importance of oxygen and moisture and the effectiveness of these soap lubricants. In most industrial processes sliding speeds were much higher than in laboratory experiments, and this led to an anomaly in the merits of different soaps. If the argument of Bowden and Tabor about the importance of melting point were followed strictly it would seem that sodium soap should be superior to lime soap at high speeds because its melting point was higher. In fact, the reverse was the case. This and other similar anomalies suggested that attention should also be directed to what might be called the rheological properties of the soap, which might be of considerable importance in high-speed metal working processes. Dr. Barwell, commenting on these remarks, said that, although they had not done experiments at the speeds referred to, he could only explain differences in behaviour of different soaps (for example, oleates and stearates), as the temperature was raised by differences in their rheological properties.

There were several other speakers during the course of the discussion. Differences of opinion were revealed on methods of carrying out micro-hardness tests. At the request of Dr. Kramer, of Braunschweig, Professor Andrade drew attention to Kramer's work on the spontaneous emission of electrons from strained metallic surfaces, and both in the morning and the afternoon Mr. L. Grunberg contributed remarks showing that the Engineering Research Laboratory, D.S.I.R., was investigating this phenomenon very closely.

The Engineers' Guild—A Review*

By ROBERT CHALMERS, O.B.E., B.Sc., M.I.C.E., M.I.Mech.E.

As the Engineers' Guild has now entered upon its fifteenth year, the occasion seemed fitting to the author for a general review of the ideas that led to its formation, and their subsequent development and application.

Constitution.—A meeting of engineers on November 17, 1937, appointed a committee "to investigate the possibility of improving the status of the professional engineer." That Committee, which I shall call "The Status Committee" for short, readily decided to recommend the formation of an Association or Guild of the profession, but the question naturally arose as to who were to be admitted, as professional engineers, to the membership of the Guild. The meeting at Caxton Hall, to which the Committee reported on May 16, 1938, decided the question for the time being, by inaugurating the Engineers' Guild with a membership restricted to corporate members of the major Institutions. The reason at that time was, I think, mainly caution ; a restricted scope of membership could, if thought fitting, be expanded, and it was thought better not to take the risk of a wider scope which would be difficult or impossible to contract. But already even then the principle was foreshadowed which the Council later formulated in a Resolution, taken on July 7, 1948, in these terms : "The Guild claims for the engineering profession parity of status with any other profession. A necessary basis of such a claim is that each member must possess a general qualification of a definite high standard, whatever special qualifications he may have. It is considered that the three major Institutions adequately provide that definite high standard of general qualification." There has been much discussion of this subject at Guild general and branch meetings, but in September, 1950, the Guild as a whole, in adopting the terms of the present Memorandum and Articles of Association, confirmed, by a majority of 1179 to 25, that only corporate members of the Institutions of Civil, Mechanical and Electrical Engineers should be admitted to Guild membership, and only non-corporate members preparing to qualify as corporate members of these three Institutions, should be admitted to Associateship of the Guild.

Connection Between Status and Remuneration.—The conveners of the meeting which appointed the Status Committee declared its purpose to be discussion of "suggestions for the Improvement of the Salary and Status of the Engineer." The general sense of the meeting, however, was that to put salary before status was reversing the proper order. The idea that status must come first is still, I think, characteristic of the general feeling of Guild members and is embodied in the expression of the Guild's objects stated in the constitution : "To promote and maintain the unity, public usefulness, honour and interests of the engineering profession."

It is obvious, however, that there is a close connection between the status of a profession and the remuneration of its practitioners. They react upon each other and although unity, public usefulness and honour may have precedence, they cannot be promoted fully if professional interests be neglected, and the Guild does not neglect consideration of remuneration.

[At this point Mr. Chalmers gave a review of the energetic activities of the Engineers' Guild on matters affecting remuneration. We turn to his later remarks about the status of engineers.]

Status

The Value of Intercourse.—During the proceedings of the Status Committee, an engineer who then held a leading position in the profession expressed the view that one cause of their existing unsatisfactory status was that engineers, when young, were apt to be confined too closely to the drawing-board or the laboratory bench, with the result that they lacked interest in and appreciation of administrative and financial considerations and were apt to be careless of dress, appearance and deportment,

* Engineers Guild. Address to Metropolitan Branch, October 23rd : repeated Southern Branch, November 27th. Extracts.

and to be lacking in social adroitness, negotiating ability and wider cultural interests.

In so far as that may be valid criticism, I think that the contents of the *Guild Journal*, the subjects of consideration and discussion at branch meetings, and indeed the whole of the intercourse promoted by the Guild, must tend to encourage members to wider views and interests, to knowledge of the world and its ways, to comprehension of the manifold activities and aspects of the community to whose service their profession is devoted, and to a sense of proportion in appreciation of their relations with that community.

Administration and Management.—Among the immediate aims announced by the Council in 1948 were : (*a*) representation of the engineering profession at the highest levels of planning and control, and (*b*) acceptance of engineers as eligible candidates for the most responsible administrative posts. A committee appointed by the Council to inquire into the facts in these respects on the basis of information at the disposal of members of the Council and of Guild Committees reported that engineers are, in fact, accepted in both of those categories, " provided that, in addition to their technical abilities, they have the necessary outstanding personality and ability in other essential fields." I do not think that is true of the Civil Service. Assuming it true elsewhere, I should be inclined to conclude that an insufficient number of engineers possess the necessary qualities, as otherwise there would be more engineers where they are so much needed as members of directing bodies of the class, say, of the National Coal Board. In furtherance of such ideas the Council in 1950 recommended branches to consider instituting series of lectures on administration and management. So far as I know, the branches did not adopt this suggestion to any considerable extent, and it would be interesting to know why. I hope it was not due to any prevalence of the notion I have sometimes heard expressed that the man who takes to administration ceases to be an engineer, with the implication that he is therefore a sort of renegade whom the Guild should not encourage or countenance. An expression of this kind appeared in a recent number of *Chartered Civil Engineer*, in which someone was quoted as saying that " there is nothing more pathetic than the engineer who has lost his technical ability because of the preponderance of his administerial duties." I think that is complete nonsense. The technical ability in many detailed respects may in such cases diminish for want of practice in application, but the general engineering training and frame of mind persists, and the result is by no means pathetic. On the contrary, the demonstration that an engineering background is an asset in administration enhances the prestige of our profession and is a public benefit. I hope the Guild will continue to welcome, and to benefit by intercourse among qualified engineers of every variety, and to promote opportunities for, and encourage each of them to development of his fullest possibilities in whatever direction his gifts may tend to.

Ethics.—The Status Committee, in their report, said : " the fundamental concern of the Engineers' Guild visualised by the Committee is ethical, not scientific ; the duty of one engineer to another and the inter-relation of profession and public." From the Guild's earliest days members have from time to time suggested that a code of professional ethics is required. So far as I know, however, no one has yet suggested any specific respect in which the code contained in the By-Laws of the Institution of Civil Engineers needs to be supplemented. Of course, it does not follow that that code is complete and final ; but supplemental provisions cannot be made by a process of invention. They must be based on consideration of actual experiences. Two ways occur to me in which the subject might be developed.

(*a*) I think that the present General Council would probably be prepared to implement an offer made by the Foundation Council to set up, if required, the means of confidential consideration of any cases submitted to it of doubts in members' minds or of differences between members.

(*b*) Members' past experiences of instances of doubtful conduct, told without identifying the parties concerned, might furnish a topic for discussion at branch meetings.

Codification might be evolved from experience of the results of such consideration and discussion.

A subject of interest in this connection was recently debated in General Council. Ought the Guild to adopt a policy of persuading employers to require continued membership of the appropriate Institution as a condition of continued employment ? The branch from which the suggestion came declared two objects. One was relief from income tax on the amount of subscription to the Institution. The other was furtherance of the principle that only engineers holding Institution qualifications should be employed on work requiring professional skill. The proposal was strongly opposed by some members of Council as an infringement of liberty to resign from membership of the Institution because of possible serious disagreement with Institution policy or activity. The proposal seemed to them to be akin to inviting employers to enforce a " closed shop." On the other side it was contended that the so-called " closed shop " had reference only to membership of trade unions or protective associations, and had nothing to do with membership of learned societies conferring qualifications. It was argued that an engineer ceasing to be a member of his Institution ceased to be qualified, and was in a position analogous to that of a solicitor whose name ceased to be on the rolls, or of a doctor whose name ceased to be on the statutory register. Disagreement was profound, and the question remains for the present unresolved.

Advice to Individual Members.—The Status Committee suggested that " legal and other professional assistance might be provided for members to combat injustice." So far as I remember, the Council did not take the initiative in developing this suggestion by offering a service of some such nature to members. Naturally, however, members experiencing or apprehending injustices or faced with problems of various kinds affecting their professional honour or interests turned to the Guild for advice. The occurrence of such cases began to be reported to the Council in 1948. They were sympathetically received, a very considerable service of this kind to members has developed, including legal advice when required, and its existence has become known through the Guild's *Journal*. The nature and details of individual cases are, of course, treated as strictly confidential. I hope, however, that it may soon be possible for the committee concerned to classify the issues that arise and make known, for the benefit of members generally, the lessons to be learned from the experiences of some of their fellows. Some of those experiences, no doubt, will contribute to the consideration of professional ethics. Others are purely practical and it is known that, for instance, a young member negotiating a new contract of employment sought Guild advice and benefited therefrom by £150 a year and improved conditions as well.

Delegation to Branches.—This function of advising individual members has recently been delegated to branches, subject, for an initial period at least, to guidance from headquarters in the light of experience already gained. I hope that the delegation of functions to branches may be carefully, but progressively, developed. Rightly or wrongly, I have a feeling that the accession of increased membership would be promoted if it should become known that the branches are promoting the Guild's objects in their districts by various activities additional to the holding of discussion meetings and social functions.

Associates.—Associates of the Guild are prospective members, young men for the most part, preparing for full qualification, but not yet of " Chartered " status.

The Guild has at present some 450 associates, although, until recently, no special effort to attract them has been made. That is not because they are not wanted, but because it seemed right for an initial period, to concentrate on the recruitment of ordinary members. All present members and associates of the Guild will be glad to see many more associates and to find them making their presence and their views a real influence in the conduct of Guild affairs.

Registration.—Questions of the desirability and practicability of statutory registration of the engineering profession were present to the minds of the Status Committee and the Foundation Council, who both considered that the subject required much more thorough investigation than they could give to it. The interest shown by Guild members in this subject led the Council to appoint a Committee early in 1949 to conduct that investigation. The report of that Committee is now in course of being made available for discussion in the branches, and as such discussion will occupy at least one whole meeting of each branch, I do not propose to refer further to the subject on the present occasion.

The Guild Journal.—Pre-war publications in connection with the Guild were the Report of the Status Committee in 1938, a booklet issued by the Foundation Council later that year, setting forth its proposals as to policy and activities, and a Bulletin in 1939, giving an account of subsequent events. The first number of the *Journal* in its present form was issued in November, 1946, since when its appearances have increased in frequency from about three to the present regular six each year. It has attracted compliments from outside the Guild, has sometimes been quoted in the public technical press and is, I believe, found very satisfactory by members generally. Some members in the provinces have told me that they regard it as the most valuable of the Guild's internal activities.

Watch on Advertisements.—Internal activity is a necessary forerunner of the Guild's external activity, which had its practical beginning early in 1947 with a successful remonstrance addressed to Australia House, whose advertisements inviting professional and other immigrants, called for " mechanical engineers " under the heading of Manual Workers. Many inquiries and remonstrances have since been addressed to advertisers and to newspapers whose publications have failed to treat the engineering profession with proper respect, by offering inadequate salaries, by omission of, or error in, specification of proper qualifications, by references to the profession under wrong headings and omissions under the right ones. On the whole, the endeavour to educate these people has had a considerable measure of success.

Relations with Foreign Engineers.—The promotion of good relations with engineers in other countries has from the beginning been considered desirable, and a representative of a French association of engineers, bringing friendly messages, was welcomed at the Guild's first annual general meeting in May, 1939. In 1951, however, the Council felt constrained to decline an invitation to join an international federation of societies more or less similar to the Guild, partly because the suggested activities seemed to overlap those of international organisations in which the Institutions are concerned, but more, perhaps, because it was considered that for the present the Guild's energies and resources are all needed for the home country and the colonies.

Publicity.—The education of the public to appreciation of what they owe to the engineering profession is an obvious means of advancing status. The Guild's first honorary member, Mr. Loughnan Pendred, writing to me on April 3, 1939, suggested that the Guild could attract notice by publishing a memorandum on a subject of wide interest, and he suggested investigation of, say, " The Effect of the Automatic Lathe on Employment." He hoped that by some such means " the Guild would come at once into the public eye, and would be exercising a function which I hope to see it develop—that of relating engineering with general social science." It will be well to keep this, and other similar suggestions, in mind as possible means of useful Guild enterprise when resources permit.

The Guild made an attempt to correct the lack of press notice of the engineers' contribution to the Festival of Britain. This was ineffectual, but educative, for it was learned that the effort ought to have been made, not after the

Festival had been opened, but at least a year in advance. In this and other matters it has become clear that lack of press notice of engineering achievement is largely due to the engineers' own excessive reticence. Endeavours to show engineers the value of press attention and the means of obtaining it have been made through the Guild's *Journal* and by communications to the Institution of Civil Engineers and the Association of Consulting Engineers, with, I think, some effect. The Guild itself has recently attracted press notice mainly because its actions have been of public interest, but also because the Guild has given the press every opportunity to know of those actions.

The Gardiner Committee.—The Gardiner Committee was appointed by the Treasury to advise on the future organisation, structure and remuneration of the Works Group of Professional Civil Servants, which comprises many architects, engineers and surveyors in various Government departments. Here was an example of the Guild's co-operation with organisations representing sections of the profession, by the supply of information to the Institution of Professional Civil Servants. The Guild, also, however, furnished its own evidence direct to the Committee, largely to the effect that not only technical functions but the administration and direction of engineering should be in the hands of engineers, freed from detailed control by lay administrators and having direct access to Ministers.

Waddington Constitution Commission.—The British Guiana Region of the Guild's Overseas Branch submitted a memorandum to the Waddington Commission on the Constitution of the Colony, pointing out the great part that engineering must have in its development and prosperity, and the need for such work to be under qualified engineering direction and administration, and recommending that Heads of Engineering Departments be made Secretaries to Government and ex-officio members of the Legislative Council, and that engineering should be represented in a Second Chamber if such were decided upon.

Road Accidents.—Arising out of the very serious accident at Chatham, in which a number of cadets were run down by a bus, the Guild has urged on the Minister of Transport that, as in the case of railways, serious road accidents ought to be the subject of inquiries conducted by professional engineers experienced in highway and traffic matters.

River Boards.—The Guild has made representations to the Ministry of Agriculture and Fisheries, and to the Boards created under the River Boards Act, 1948, to the effect that, as the work of the Boards is primarily of an engineering character, the positions of their engineers among their other chief officers should be, in status and remuneration, second to none.

Regional Hospital Boards.—Several Regional Hospital Boards, although empowered to appoint Regional Engineers, have appointed instead assistant engineers in their Architect's Departments. The Guild has made repeated representations to those Boards and to the Ministry of Health as to the much greater economy and efficiency which would result from putting all engineering in charge of Regional Engineers directly responsible to the Boards.

Ministry of Works.—It has been found that, although engineering is predominant in the works carried out by the Ministry of Works, yet the Director General of Works, his deputy, the Director of Maintenance Services, and all Assistant Regional Directors, are either architects or surveyors. The Guild has set its hand to the task of obtaining correction of this and other hindrances to engineering efficiency and engineer status.

Kent County Council.—The Guild, in co-operation with the Association of Local Government Engineers and Surveyors and other bodies, made energetic protests against a proposal by Kent County Council to place a new County Surveyor in a position of real or apparent subordination to the County Clerk, and circularised many Chartered Civil Engineers advising them not to apply for the post under the proposed conditions.

Edmonton Borough Council.—The Guild took action against an attempt by the Edmonton Borough Council to compel a new borough engineer and surveyor to be a member of a trade union.

Durham County Council.—The Guild, at first on its own account and later, by its representatives on the Joint Emergency Committee of six professions, took energetic action against the attempt by Durham County Council to compel its professional employees, including engineers, to be members of Trade Unions or of professional organisations.

Success.—It may be asked what success has been achieved as a result of the Guild's evidence to, or representations to, or action against, these various bodies. The answer is that in the last three cases I have mentioned complete success has already been attained, and that in the others there has been some partial success, but the results are not yet known because, although faced in some instances by rebuffs, the Guild has not dropped any of them. Either the objects sought are being pursued, or the best means of pursuing them further is being investigated. I hope that everyone here will recognise that they are all worthy objects and that the greater the support afforded by members of the profession to the Guild, the more quickly and the more completely will success be attained. I confidently claim that the Guild, young as it is, has already made a substantial contribution to enhancing the prestige of the engineering profession in this country and deserves, and ought to have the support of every member of the profession in the tasks to which it has set its hand and in the greater tasks which lie ahead.

A National Council of Engineers

In conclusion, I would ask for your attention to the words of a full page article published in The Engineer on May 27, 1938, at which time the editor was Mr. Loughnan Pendred, a Past President of the Institution of Mechanical Engineers.

After greeting the foundation of the Guild the article went on: "... the time is ripe for the establishment of a General Council of Engineers which would be the mouthpiece for all the engineers in the land; a Council to which the Government could turn for advice; a Council which would direct the corporate activities of British engineers, which would guard their interests, watch over their status, seek their national and international recognition, and organise enterprises in which united effort was called for. France, Germany and America all enjoy the assistance which such Councils render to the State and the profession; the United Kingdom, a kingdom of engineers, is without one. We say, without reserve, that whatever travail may have to be gone through in its gestation or birth, such a General Council of Engineers ought to be formed and that whatever it may cost the Institutions, it ought to be made effectively operative. We do not ask for a magnified E.J.C., but for a body with both money and power. It is always objected by the Institutions that their Charters put limitations on their activities, or that they will make themselves liable for income tax if they do aught that can be construed by the Inland Revenue as of personal value to their members as entities and not solely to engineering as an abstraction. If that be true, then we should say: 'Burn the Charter if it cannot be amended, and pay the income tax if exemption from it is hampering the performance of duties to the members.' These are but paltry matters by comparison with the services to the nation and the Empire, and to the whole body of engineers which might be performed by joint action. If we are right, as we hope we are, in seeing in the Engineers' Guild the first beginning of a movement which will lead to the great desideratum which we have outlined, it will have 'builded better than it knew.' It is a movement initiated by the younger men, men who by the time they have reached ripeness will still have the experience, the eagerness and the energy to carry out a scheme which demands for its fructification young blood and young brains."

Now I think we should not take too literally the phrase I have quoted about burning the Institution Charters. I imagine it was used mainly in order to put the greatest possible emphasis on the need for the "National Council of Engineers," which the article advocated, and that in any case the author would not now commend any such conflagration. For there has, I submit, been a substantial forward movement since those words were written. It is since then that there has been formed the alliance between our three great Institutions, which is all the time being knit more closely and which has strengthened the Institutions and the profession. In addition, the Engineers' Guild, as I hope I have shown, has, in its distinct but complementary field of activity, begun at least to be an influence in the same direction. And, further, the machinery has been created for consultation between the Institutions and the Guild on matters affecting the common boundary of their respective fields. And that machinery has been used and will be further used.

In these two parallel movements, thus linked together, does it not seem to you that our profession has the means, if we have but the united will to use them, of moving forward to realisation of that vision of a National Council of Engineers, and of developing our utmost possibilities of leadership and service for the common good of the nation and Commonwealth, and of the great profession which we have the honour to follow and to cherish.

Schiffbautechnischen Gesellschaft Meetings in Hamburg

There was a large attendance at the annual meetings of the Schiffbautechnischen Gesellschaft, which were held in Hamburg from November 19th to the 22nd. On Wednesday afternoon and evening, November 19th, meetings were held of the special committees on "Ship's Propelling Machinery," under Professor Dr.-Ing. K. Illies; "Safety of Ships," under Professor Dr.-Ing. K. Wendel; "Construction and Welding of Ships," under Professor Johannes Hansen; "Resistance and Propulsion," under Professor Dr.-Ing. G. Kempf; and "Electricity in Ships," under Dipl.-Ing. Ch. Breitenstein. The same evening the council meeting took place in the Atlantic Hotel, and this was followed by a reception for members and guests.

On Thursday morning, November 20th, the members' meeting was held in the Curio-Haus, Rothenbaumchausse 9, Hamburg, under the presidency of Professor Dr.-Ing. G. Schnadel. Following the greetings of the university and other scientific societies, Dr. Schnadel gave a memorial address, recalling the fiftieth anniversary of the first paper given by Hermann Föttinger before the society on November 21, 1902. It was followed by a paper read by Director Dipl-Ing. W. Brose, of Bremen, on "The Development of the Föttinger Transmitter in World Industry and Transport," after which Professor Dr.-Ing. R. Wille, of Berlin, of the Hermann Föttinger Institute of Flow Research in the Technical University of Charlottenburg, read a paper on "Flow Characteristics of the Transition Period Between Controlled and Uncontrolled Movement."

After luncheon, which was served in the Curio-Haus, the following papers were presented:—"Working Experiences in Recent Years with the New Deutz Marine Oil Engines," by Dipl.-Ing. K. Schmidt, of Köln; and "The Technical Advance in New Building for Inland Port and Seaport Authorities," by Dipl.-Ing. H. Waas, of Bonn. The same afternoon there were meetings of the special committees on "Light Metals and Special Materials," under Director Dipl.-Ing. W. Fiedler; and "The Vibration of Ships," under Professor Dr.-Ing. F. Horn.

On Friday, the papers read included those on "Stress in Angle-Stiffened Plates," by Professor Dr.-Ing. E. Metzmeier, of Berlin; "Research on Flow and Resistance Conditions for Ships in Shallow Water," by Dipl.-Ing. S. Schuster, of Berlin; "Basic Calculations for the Use of Light Alloys in Ships," by Dipl.-Ing. Th. Domes, V.D.I., of Köln; "Magnesium-Bonded Deck, Floor Coverings and Plastics in Shipbuilding," by Director E. Stein. On the last day, Saturday, November 22nd, a series of visits was arranged.

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METALLURGICAL SYMPOSIUMS

It is a valuable and increasingly common custom for societies or groups of societies to organise a symposium or meeting for the presentation and discussion of papers on some particular aspect of the subjects in which they are interested. That such meetings, which conveniently provide a collection of individual views on one topic, are popular and stimulating is shown by the large attendances which they attract. The aim of the organisers of a symposium may be to collect together a wide variety of information on different aspects of the same broad subject, or it may be to direct attention from all possible angles to one particular problem. These different objectives are illustrated by two very successful symposiums held recently, one on "Properties of Metallic Surfaces," organised by the Institute of Metals, and the other on "Caustic Cracking in Steam Boilers," sponsored by the Corrosion Group of the Society of Chemical Industry.

"Properties of Metallic Surfaces" is a title which may cover a vast field of phenomena. Certain properties had evidently been excluded from consideration, but the thirteen papers communicated still covered an exceptionally wide range. At the morning session the papers dealt with topography of surfaces, metal surface reactions in solutions, chemical behaviour as affected by surface conditions, properties of surface films and of coatings produced by a diffusion mechanism in industrial processes for the surface treatment of metals and alloys, as well as the abrasion of calcite crystals and the high-frequency surface resistance of metals. It is not surprising that Professor Cottrell, who acted as rapporteur, confessed that he was unable to suggest any connection between the six papers of this group, although they had one thing in common: none of them was concerned with mechanical properties. The ensuing discussion was not wanting in variety, but may have lacked something in continuity of theme. The seven papers taken in the afternoon had more in common. They were concerned largely with machining, lubrication and the effect of surface condition on mechanical properties, but here again it may be thought that some division of the group would have been an advantage. Nevertheless, the discussion, though a little involved owing to the wide range of subjects considered at the same time, was of great interest and will merit careful study when in due course it is published in full.

The subject of the other symposium, "Caustic Cracking in Steam Boilers," was a precise problem; and in the papers and the discussion two aspects, materials and mechanism, and environment, were distinctly and adequately represented. The emphasis was, of course, on methods of prevention, and the attitude of the meeting towards preventive measures may perhaps be summed up as follows. Organic treatment met with no favourable comment, because the additions are generally unstable and undergo changes, which makes control by chemical analysis difficult. Phosphate treatment, theoretically the most efficient, as it provides a certain method of keeping hydroxyl-ion concentration below a harmful level, came in for criticism on the grounds of expense, non-availability of phosphates in times of emergency and the need for careful chemical control to avoid waste. Nitrate treatment had an enthusiastic exponent in Dr. A. A. Berk, of the U.S. Bureau of Mines. The inhibiting effect of nitrates is remarkable in view of the severe cracking that can be produced in nitrate solutions; but Dr. Berk, while admitting that at temperatures like 250–300 deg. Fah. nitrates might intensify the effect of caustic alkali in causing cracking, stated that there was no such danger at the operating temperatures of boilers. At such temperatures an adherent, protective film of oxide was formed, which persisted and continued to afford protection when the temperature fell. Nitrates were subject to some degree of decomposition in contact with steel, but he denied that chemical control tests offered any great difficulty. It seemed that support for the sodium sulphate treatment recommended by the B.S.I. diminished considerably during the reading of the papers and the early part of the discussion, but gained in force later, when it became clear that many of those who were accustomed to, and satisfied with, its use would not like to change unless some very good reason was shown. In opening the discussion, Sir Harold Hartley had expressed the hope that those taking part would give a lead on future policy; but it was evident that the meeting was not prepared to draw up an order of merit of different processes; in fact, the best under one set of conditions might not be the best under all. It may be that the differences of opinion will persist until the problem solves itself by the replacement of riveted by welded construction.

NEW PROBLEMS IN THE AIR

There could hardly have been a better or more lucid exposition of certain of the problems now facing those in charge of our airlines than that given by Sir Ben Lockspeiser in his presidential address at Belfast to the British Association. Recent years have seen, on the one hand, an extraordinarily rapid rate of increase in the power of the new turbine engines, and in the speed of air travel; with, it must be admitted, however, a regrettable increase in the size and cost of airports. On the other hand, there has resulted a great expansion in the number of those who wish to take advantage of the ease, and increasing safety, of air travel. Increased safety must have had much to do with the increase in popularity of flying. It is proudly claimed in the last report of the British Overseas Airways Corporation that, during the four-year period July, 1948, to June, 1952, in which some 2,000,000 passenger-miles were flown, there was not a single fatal, or even serious, accident to any passenger. And the record of the B.E.A. Corporation was not far behind. Not all the features of air travel can be claimed to be as satisfactory, least of all that of the alarming growth in airports; in fact, Sir Ben Lockspeiser went so far as to suggest that if aircraft continue to increase in landing speed and weight, the main economic problem in aeronautics will become less a matter of anything that may take place in the air than of what happens on the ground!

In the last few years, the flying-boat type of aircraft has experienced a sad lack of favour despite its improved aerodynamic efficiency and the gain in its general layout consequent on the absence of airscrews from the propulsive element. Now, it happily looks as though this loss in popularity may be put into reverse. The denser the air traffic, the larger the aircraft needed, and even more intense the airport problem. One way out may well prove to be a greater use of very large flying-boats. Airport costs can then become far less onerous; a welcome change, for the existing "London Airport" is known to have already cost £10,000,000 sterling, and may cost £20,000,000 by the time it is completed. Moreover, the gain in public amenity by the removal to the coast of noisy landings and take-offs, far from the proximity of populous areas, would be immense. On the economic side, the saving of thousands of acres of potentially agricultural land in this over-crowded island is a matter of no small importance. Among the objectives

in current research programmes are the use of prestressed concrete in runways, the possible insertion of a foundation layer of water bags, and even the total abolition of undercarriages in favour of "belly landings" and the use of catapults, and arrester gear, as on certain aircraft carriers. Another complex problem, on which expert views are divided, is whether the delta types of aircraft should have their control surfaces carried by a tail structure. It may seem simpler for such surfaces to be worked into the wing itself, but may not this make control more difficult for the pilot ? The research staffs of the air corporations are, of course, fully alive to such questions, and the prospect of improving financial resources in the coming years will certainly help to encourage solutions. It is very gratifying to read the recent statement of the B.O.A.C., that the year ended in March last, showed a surplus of £275,000, contrasted with a deficit of £4,600,000 in the previous year, and of as much as £7,800,000 in the year before that. This greatly improved position is perhaps even better illustrated by the fact that whilst in 1948 the revenue earned per employee was only some £600, it has now risen to over £2000.

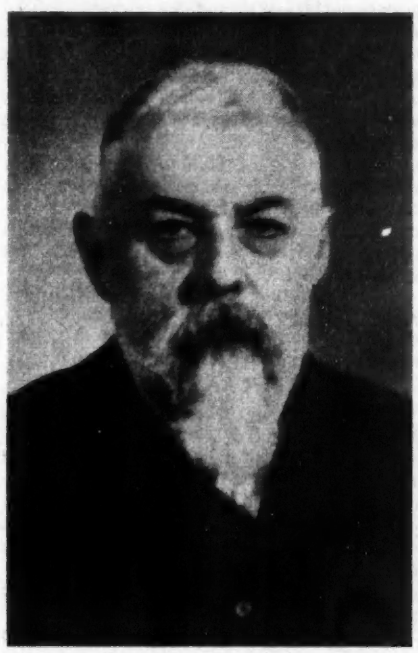
If our other Airways Corporation has been less fortunate, it must be remembered that, apart from other factors, the traffic to and from the Continent could not fail to be adversely affected by the present restrictions in holiday expenditure allowed to such travellers. It is known that this Corporation hopes that its difficult task of traffic control will in future years be assisted by the use of enlarged and improved kind of rotary wing aircraft. Sir Ben Lockspeiser goes further and speculates on the possible application of foldable lifting-rotors to fixed wing aircraft solely for use when taking-off or landing. By such means, it is suggested, might our present airport difficulties, or some of them, find assistance towards solution. Herein, indeed, is a challenge to skill and ingenuity. Professor F. E. Simon reminds us, in the current issue of the *Atomic Scientists News*, that a country like the United Kingdom, which has few natural resources but plenty of scientific and technological genius, must, in the end, depend on the products of this genius for its livelihood. If British aircraft designers can do as well in solving these current air problems as they have in those necessary to the production of the new civil airliners coming into service, there can be little doubt of their retaining the prominent position they now hold in the esteem of the engineering world.

Obituary

Dr. G. V. LOMONOSSOFF

As recorded briefly in our last issue, the death of Dr. G. V. Lomonossoff occurred in Montreal, Canada, on November 19th. Dr. Lomonossoff, who was a railway engineer, lived in this country for nearly twenty years until 1948, when he left England to take up residence in the home of his son in Canada. He was in his seventy-seventh year.

George Vladimir Lomonossoff was born in Russia on April 24, 1876, and received the early part of his education at the First Cadets School in Moscow. He graduated at the Institute of Transport, St. Petersburg, in 1898, and then spent two years in the locomotive testing department of the Kharkoff-Nicolauf Railway. In 1901 Dr. Lomonossoff was appointed lecturer in railway engineering and subsequently Professor of Railway Engineering and Economics, at the Kiev Polytechnic Institute. He remained there for six years, during which time the Institute conferred upon him his D.Eng. degree. Lomonossoff's next appointment, which he held from 1908 to 1910, was as chief mechanical engineer of the Tashkent Railway, and then, for ten years from 1911 to 1921, he was Professor of Railway Engineering and Economics at the St. Petersburg Institute of Transport. During that period he held many other offices, including those of president of the Locomotive Research Bureau, chief mechanical engineer of the Nicolas Railway, assistant director-general of Russian Railways, member of Russia's supreme engineering council, Under-Secretary of Transport, and president of the Russian War Railway Mission to the U.S.A. In this last appointment, in the latter part of the first world war, Dr. Lomonossoff was responsible for the design and ordering of somewhere in the region of 2000 locomotives. In 1921 Lomonossoff was appointed High Commissioner for Railway Orders, and about that time he put forward a proposal to the Russian Government for the building of a number of diesel locomotives. At first the proposal was rejected, but subsequently—as High Commissioner for Diesel Locomotives—Dr. Lomonossoff was authorised to arrange for the building of three diesel locomotives.



Dr. G. V. Lomonossoff

In the latter part of 1925 Dr. Lomonossoff came to this country with an introduction to Sir. W. G. Armstrong Whitworth and Co., Ltd., and subsequently there was placed with the firm an order for the building of a 1200 b.h.p. diesel locomotive, designed by an engineer named Schelest. By the end of 1926, considerable progress had been made with the locomotive, but the costs had risen and it has been said that Russian Government officials were expressing some doubts as to the possible usefulness of the engine. Ultimately, Sir W. G. Armstrong Whitworth and Co., Ltd., was instructed to cease work and ship the locomotive to Russia in its unfinished state. A few years later, when Dr. Lomonossoff had taken up his residence in this country, he contributed a paper to the Institution of Mechanical Engineers on the subject of "Diesel Traction," in which there was included a good deal of information about the Schelest locomotive.

Prior to settling in England, Dr. Lomonossoff undertook some research work in Germany—where he received the Dr. Ing. degree at the Technische Hochschule, Berlin—in connection with locomotive testing. He also spent a year in the U.S.A. lecturing at the California Institute of Technology. His lectures there subsequently formed the basis of his book entitled *Introduction to Railway Mechanics*, which was published by the Oxford University Press in 1933. For some years during his stay in this country Dr. Lomonossoff was associated with consulting work undertaken by Messrs. Hitchins, Jervis and Partners, of Westminster. He was elected a Member of the Institution of Mechanical Engineers in 1931 and made his first contribution to its *Proceedings* in the same year. This was a paper entitled "Problems of Railway Mechanics," in which he suggested that ignorance of railway mechanics was responsible for "the failures of many of the attempts made in the last five years to change radically the form of the locomotive as given by George and Robert Stephenson." Dr. Lomonossoff's next paper to the "Mechanicals" was that on "Diesel Traction," to which reference has already been made. Some years later, in collaboration with his son, Lieut.-Colonel G. Lomonossoff, R.E.M.E., he presented a paper to the Institution of Mechanical Engineers on "Condensing Locomotives." Just prior to its publication in the *Proceedings*, Dr. Lomonossoff contributed a series of articles on the same subject to THE ENGINEER. Those articles appeared between July 7 and September 22, 1944, their preparation affording us several months of constant association with their author. His extensive technical knowledge and careful attention to detail together with his genial personality, are some of the characteristics of Dr. Lomonossoff which will long be remembered by the numerous engineers in this country and abroad who were acquainted with him.

BOOKS RECEIVED

Direct Current Machines for Control Systems. By A. Tustin. London : E. and F. N. Spon, Ltd., 15, Bedford Street, Strand, W.C.2. Price 50s.

Structural Steelwork for Buildings. By H. P. Smith. London : Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 7s. 6d.

Principles and Practice of Prestressed Concrete. By P. W. Abeles. London : Crosby Lockwood and Son, Ltd., 39, Thurloe Street, S.W.7. Price 21s.

Les Engins Mecaniques de Chantier. By Adil Gabay. Switzerland : Librairie de L'Universite F. Rouge and Cie., Sa., 6, rue Haldimand, Lausanne.

Proceedings of the Engineering Production Convention. Australia : The Institution of Engineers, Science House, Gloucester and Essex Streets, Sydney.

Foundations of Engineering Science. By Leslie Pilborough. London : Blackie and Son, Ltd., 16–18, William IV Street, Charing Cross, W.C.2. Price 15s.

English-French Vocabulary of Aeronautical Terms. Prepared by M. Chalmette. London : Bunhill Publications, Ltd., 12, Bloomsbury Square, W.C.1. Price 4s.

Locomotive and Train Working in the Latter Part of the Nineteenth Century. By E. L. Ahrons. Cambridge : W. Heffer and Sons, Ltd. Price 15s.

Teach Yourself Mechanical Draughtsmanship. By S. M. Hood. London : English Universities Press, Ltd. Saint Paul's House, Warwick Square, E.C.4. Price 6s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SIMPLICITY IN GEARS

SIR,—I regret to find that your editorial of November 21st seriously misrepresents my remarks in the discussion of Professor Tuplin's paper to the British Gear Manufacturers' Association. I did not say that because the tables of involute functions prove convenient in certain mathematical problems they should therefore be used in gear technology. What I did say was that I am unable to see why there should be any special objection to the involute function, which is only an ordinary trigonometric function for which tables are available. Expressed in other terms than the tabular values, the trigonometric functions can all be made to look inconvenient and formidable, but we regard them as "elementary" functions and use them without difficulty. We also find that they have uses other than with reference to problems of right-angled triangles and I mentioned as a matter of interest that the involute function shares this property and is conveniently the integral of $tan^2\theta$.

Neither did I say that the different uses to which screws and worms are put should make us discard those factors which they have in common. What I did say was that the argument used by Professor Tuplin, that because certain dimensions were convenient for use in a screw we should necessarily use these in worms, was based on false analogy, since the screw is used with a mate which is its female replica, whilst the worm is used with a mate which is its envelope when the two are rotated on skew axes. To amplify this distinction, we may consider the fact that screw threads are normally made straight-sided on the axial section. Professor Tuplin's argument would suggest, if carried to its logical conclusion, that we should therefore make worms straight-sided on the axial section, whereas, of course, we are agreed that worms should be involute helicoids.

Finally, my comment on the selection of axial pitch was that the axial pitch which was convenient to give simple change gears on one machine might not be as convenient on another and consequently different manufacturers might choose to use different axial pitches for the same nominal gear with unfortunate results to the user who expected nominally identical British Standard gears from different manufacturers to be interchangeable. My comment on the bevel gears was not that Professor Tuplin's proposals should have covered them also but merely a passing reference to the fact that the change gear calculating fraternity, who, according to Professor Tuplin, might be opposed to his proposals in order to keep themselves employed, would remain in business so long as bevel gear generating machines had different change gear characteristics from those of helical gear generating machines.

EWEN M'EWEN

University of Durham, November 26th.

PREMIER GRADE PETROL

SIR,—Mr. Ault in his letter in your issue of November 14th, points out that the advancing of ignition timing on existing engines using premier (i.e. premium ?) grade petrol should not be overlooked and will give economy. Recollection of the timing lever on motor-cycle tanks and handlebars thirty-eight years ago had well engrained the effect of this factor.

However, observations on two cars fully advanced on Pool showed no pink on an old car and, it might be said, insufficient pink on a new car to outweigh much premium on premier, with no apparent great difference in liveliness in the latter case over the range of adjustment provided.

By "pink" is meant a detonation knock as opposed to a knock due to a loose-jointed rattle, which latter is soothed by retarding the spark and presumably would still be so on premier.

With Pool still available when premier arrives, it will be possible for all drivers of present cars to prove the pudding.

A. J. FIELD

Falkirk, November 24th.

LOCOMOTIVE PERFORMANCE

SIR,—Referring to the interesting article entitled "British Locomotive Performance in Practice" (THE ENGINEER, October 17, 1952), in addition to engines of the L. and N.W. "Alfred" class and the Caledonian "140" class, those of the G.E. "Claud Hamilton" class also have deep fireboxes between the coupled axles. The "Clauds" have balanced slide valves and superheaters have been fitted to their boilers. The article does not give the date of the run recorded, but if the engine was using saturated steam it must have been many years ago.

Turning to the article entitled "French Railway Electrification," it is interesting to note that the "Rapide" express repeatedly attained speeds in excess of 90 m.p.h., and that the average speed over a distance of 318 miles was no less than 79 m.p.h. What a contrast with conditions in England! What is the explanation? France was overrun by the Germans and her railways very severely damaged, yet in 1952 the tracks are safe for speeds in excess of 90 m.p.h., whereas in this country the condition of the permanent way is said to be responsible for the low average speeds of main line trains. How can a vanquished, devastated country achieve results apparently beyond the power of a victorious nation whose land was never invaded?

E. B. PARKER

Little Sutton, November 22nd.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

SIR,—The secretary of the I.B.A.E., in his letter in your issue of November 28th, in fact, admits that the Institution of British Agricultural Engineers as such had no part in the establishment of the M.Sc. in Agricultural Engineering in this university. The difference between the support of an idea by the president of the Institution, on the one hand, and taking part in the establishment of the course, on the other, should require no elaboration.

I am, of course, not surprised that Mr. Slade should disagree with my views about the policy of the I.B.A.E., but his implication that membership of a body precludes one from criticising its official policy in whose framing one has had no part, is a very dangerous doctrine to which, I trust, neither you, Sir, nor your readers subscribe.

EWEN M'EWEN

University of Durham,
King's College,
Newcastle upon Tyne, November 29th.

Electrical Exports

AT a luncheon held in London on December 1st to mark the publication of the second edition of the BEAMA Catalogue, Sir Harry Railing, president of BEAMA, proposed the toast of "Exports and the Electrical Industry." To help the catalogue in its task of promoting the export of electrical plant and goods, Sir Harry made a number of requests. The first was that the responsible Minister should give Lord Citrine, chairman of the British Electricity Authority, more of the raw materials for the production of electricity in the coming years. The second request was that the Government should not kill the home trade by excessive purchase taxes; the third was that taxation should be reduced so that Great Britain could maintain her industrial health. He pointed out that the electrical industry employed some 600,000 workers, that the country's electrical exports totalled £190 million in 1951, and were expected to reach £210 million in 1952, which would be about 7 per cent of her total exports. Great Britain and the U.S.A. were, he said, the two greatest exporters of electrical equipment. The object of the BEAMA catalogue was to show the world what the British electrical industry could make; the second edition, which had a circulation of 16,000 copies, contained 1000 pages and had a glossary in five languages—English, French, German, Portuguese and Spanish. Mr. H. R. Mackeson, M.P., Secretary for Overseas Trade, who replied to the toast, emphasised the need for increased exports. He deplored the use of Government subsidies, but suggested that, if the industry's competitive power should hinge on credit terms, the Government might consider some extension of payment in cases where it seemed justified, subject to the limited reserves available. Referring to the industry's export problems, Mr. Mackeson stressed the importance of developing and expanding trade with South America; large-scale capital development was taking place there. A fruitful market for electrical equipment existed in Venezuela, for example—only 7 per cent of her imports at present came from Great Britain. Mr. Mackeson said that his North American tour had convinced him that Canada offered a good market for British electrical goods and the same conditions held elsewhere in the Commonwealth.

A Prestressed Concrete Bridge Structure in Florida

A DESIGN for trestle bridge spans in prestressed concrete with a length of 17,424ft is at present under construction in the United States to form part of a 15-mile toll bridge across the Lower Tampa Bay in Florida. The design embodies the Lee-McCall system of prestressed concrete, a British development in which high-tensile steel bars replace the more usual prestressing wires; the system was described in THE ENGINEER of April 21, 1950, and July 6, 1951, page 6. The toll bridge stretches between St. Petersburg and Palmetto, its 15 miles including 10 miles of hydraulic fill, a double-leaf bascule with concrete approach trestles, two other steel bridges, and two prestressed concrete trestle crossings.

The prestressed design uses trestle centres of 48ft. as compared with 36ft for an alternative reinforced concrete design, and precast prestressed beams with an *in situ* roadway deck slab, 6½in thick, supported by the prestressed beams.

Six beams are used for each bent, spaced 6ft apart under the roadway, which is of 28ft clear width with the footways cantilevering out beyond. The design allowed for H20–S16 highway loading, which for spans of the order of 36ft and 48ft is not much different from the Ministry of Transport highway loading in this country. The pile trestles are arranged so that every third trestle has raking piles to provide lateral stiffness to the bridge. The prestressed concrete design made a very great economy in the quantity of steel required in the beams and is also expected to make a substantial economy in the cost of the formwork and handling, which, it is thought, is probably not adequately disclosed by the tenders. The economy in total weight of steel is, however, not large compared with the reinforced construction, mainly due to both designs using ordinary reinforced concrete deck slabs. The total length of the prestressed concrete structure is 17,424ft, being 363 spans, for which 2178 beams are being made. As the beams had to be designed to be made and stressed at the yard at Port Tampa and then transported to the bridge, and while the deck slab was being poured, to support the weight of the wet concrete, there were in all four stress conditions to satisfy.

The contract work based on the Lee-McCall system amounted to some 8,000,000 dollars, about 150,000 dollars cheaper than any of the alternative designs, namely, two prestressed concrete designs using different systems of prestressing, and a reinforced concrete design. Because of the need to conserve steel in this country, production in the United States of the "Macalloy" steel used with this method has been arranged, but steel is being supplied from this country until production there is under way.

The Iron and Steel Institute

AUTUMN GENERAL MEETING

No. I

THE autumn meeting of the Iron and Steel Institute was held on Wednesday and Thursday, November 26th and 27th, at 4, Grosvenor Gardens, London, S.W.1. The president, Captain H. Leighton Davies, occupied the chair, except during the afternoon of the first day, when his place was taken by Mr. James Mitchell, president-elect.

In his opening remarks, the president referred to the fact that Her Majesty The Queen had been graciously pleased to become Patron of the Institute. That, he said, continued the honour which the Institute had had before.

The president went on to say that the Council had nominated Mr. James Mitchell, C.B.E., of Stewarts and Lloyds, Ltd., for election as president at the next annual general meeting. Mr. Mitchell joined the Institute in 1918, became a member of council in 1944, and vice-president in 1946. He had served as honorary treasurer since 1949. With regard to the membership of the Institute, the president said that he would like to see the membership pass the 5000 mark. He hoped that that aim would be achieved.

The secretary, Mr. K. Headlam-Morley, announced that Mr. C. R. Wheeler had been elected a vice-president, and Mr. B. Chetwynd Talbot a member of council. About future meetings, the secretary said that at the request of the Ministry of Supply a meeting had been arranged to discuss boron in steel. It would be held on February 18, 1953. Two American experts were coming over, and it should be interesting to hear what their claims were for boron and what was the experimental evidence in support of the claims. The annual general meeting next year would be held on April 29th and 30th, with the dinner on April 29th. The papers would probably include groups on sintering and other methods of ore preparation; traffic control in works, and temper brittleness. Two meetings overseas had been arranged. The Jernkontoret had invited the Institute to visit Sweden next year, and the council accepted the invitation with great pleasure, but, owing to the Coronation, it had been necessary to postpone the meeting until 1954, and the visit to Sweden was now likely to take place in the second and third weeks of June, 1954. In order to fill that gap, it was proposed to have a short meeting, a week-end or a little more, in Holland at the end of September, 1953, by invitation of Mr. Ingen Housz, of the Royal Dutch Steelworks.

The first paper to be discussed was :

COOLING OF RIMMING STEEL INGOTS IN A CASTING PIT

By R. T. Fowler and L. H. W. Savage

SYNOPSIS

Further observations have been made on the temperature distribution at mid-height of an 8-ton slabbing ingot mould between teeming and stripping, using an improved technique to eliminate possible errors and obtain fuller data. The heat lost by the steel from a horizontal slice of the ingot at mid-height has been calculated for nine casts of low-carbon rimming steel teemed in a casting pit. These results have a standard deviation of about 5 per cent of the mean value, probably owing to differences in the times from tap to teem, in the initial temperatures of steel and mould, and in the rate of heat loss from the surface of the mould.

A good correlation has been established between the change of temperature of a single mould surface reference point and the change in heat content of steel and mould, and this will facilitate fuller investigations on all the ingot moulds during a single cast.

It was found that one minute after the end of teeming all superheat had been lost from the steel, and it has been estimated that there could then be a mean shell thickness of 1½in and that heat transfer between steel and mould could be entirely by radiation.

By making a number of simplifying assumptions, estimates have been made of the rate of solidification of the mid-height slice of steel and of the temperatures at its surface and centre.

This paper was discussed in conjunction with the following papers :—" Time Studies from Casting to Rolling," by A. V. Brancker, J. Stringer and L. H. Savage ; " Mould and Ingot Surface Temperature Measurements," by A. V. Brancker ; " Ingot Mould Temperature Measurements," by R. T. Fowler and J. Stringer.

Discussion

Mr. N. H. Bacon (Steel Peech and Tozer) : What seems to come out of all this work is that non-feeder-head ingots should be charged into the soakers before they have reached full solidification. We know from our own experience that it is quite safe to do that, if they are charged just before solidification, and it seems to be particularly important since, as Mr. Savage has said, while twenty minutes may mean only a small overall heat loss, about 0·25 therm per ton, the centre temperature falls rapidly and in that twenty minutes can fall below rolling temperature, and it will take a considerable time to put the heat back again.

It is interesting to note also that this latest work supports what Mr. Robinson, of Appleby-Frodingham, told us at the Glasgow meeting, where in the discussion he showed, from actual measurements of the centre of 10-ton slab ingots, that in 180 minutes the centre temperature had fallen to 1200 deg. Cent. This is in fairly good agreement with the temperatures calculated for the 8-ton ingot. The authors assume a negligible heat transfer to the top and bottom of the ingot. In point of fact, however, the heat transferred to the bottom must be of considerable magnitude on account of the chilling effect of the bottom plate. We find that effect of considerable importance, particularly with big forging ingots. Moreover, the heat transfer to the top will be by no means negligible. I feel that further work is urgently required to see what that heat loss to top and bottom amounts to. One point which puzzles me a little is that on page 286 the authors state that the 8-ton ingot is completely solid in 160 minutes, but it seems from their diagram that complete solidification has taken place approximately 120 minutes after filling. Is that discrepancy due to neglecting the heat transfer to top and bottom ?

In their conclusions, the authors say " The technique using forty thermo-couples in a single mould cannot readily be extended to more than one mould in a cast." That is very true, " but," they go on to say, " using this correlation, a single thermo-couple (or contact pyrometer) at the reference point will enable all the ingots to be studied simultaneously to establish differences between them." I wonder whether even if such a technique were possible, and we could measure the temperature of the individual mould, having obtained that knowledge we should be very much better off. I feel that the difference in time in, say, the freezing of an 8-ton ingot within the limits of the mould temperatures which we can use and the steel temperatures at which we can tap and make a good ingot is not anything like so great as the authors seem to think from the calculations. The rule that the freezing goes on according to the square root at the time is a good working rule, and we have applied it widely. With an 8-ton ingot, will the authors say what they think are the maximum and minimum times possible with a reasonable mould temperature ? To have the mould at 250 deg. Cent. seems to be asking for trouble. Instead of attempting to find the difference between moulds it would be better to see that the moulds were at a reasonable temperature to start with, so that I do not think that the single reference point technique will be of help to us.

So far as the practical application of this work is concerned, it has shown the importance of focusing attention on the desirability of speeding up our stripping and charging. My rule is that if you square the narrow side of a slab mould and divide by 6·7 you will get the desirable time to elapse between filling and charging to the soakers, and that will enable you to charge the ingot at a point where it is somewhere near solidification, but not fully solidified. Taking a 20 square inch ingot, the formula $NS^2/6{\cdot}7$ means 400/6·7, which means that we should charge sixty minutes after filling, and we know from long experience that that is quite safe. In the case of the 8-ton Summers slab ingot, which is 42½in by 25½in, the formula gives us $25\frac{1}{2}^2/6{\cdot}7$, or 650/6·7, which means ninety-eight minutes, and if you refer to the illustrations in the paper you will find that that ingot is just about solid in 100 minutes. Taking an Appleby-Frodingham 10-ton slab ingot, which is 47in by 28in, $28^2/6{\cdot}7$ means a time of 117 minutes, and actually their figure is two hours ; the data which Mr. Robinson produced at the Glasgow meeting showed that in 120 minutes the temperature has fallen to 1390 deg. Cent. I submit that as a useful working rule for applying the lessons learned from this series of papers.

Mr. H. Brooke Freeman (John Summers and Sons, Ltd.) : There is no doubt that the fact that a reference point on a mould will give an indication of the heat changes that are taking place in the ingot in that mould is a big step forward in this work on heat conservation. Looking through this last paper, it seemed to me that the authors had in mind the time when someone would walk along a set of moulds waiting to be stripped and, using a contact pyrometer, would say, " They are now ready to strip ; away you go." The best time for stripping to take place is when there is sufficient heat left in the still liquid portion in the centre of the ingot to equalise the loss of heat which has taken place in the solidified shell. Mr. Savage has pointed out, however, that contact pyrometers which will give the temperature with sufficient accuracy are not yet available, and therefore he has resorted to the graph of mould temperature considered in terms of the time from when it was last stripped. Probably that will be sufficiently accurate for works purposes.

There are one or two points to which I should like to draw attention. First of all, there is the assumption of no loss of heat from either the bottom of the mould via the bottom plate or from the top of the mould by radiation. In Table II, looking at Trial No. 15, under the heading " Remarks," we have " Test mould held a slagged ingot, and ' blew.' " There was a covering of slag on the top of that mould. If we now look at Table V, we shall see that, taking No. 15, after eighty minutes the heat content of the steel was still 231·2 cal./g. It is necessary to go, in the remainder of the trials from No. 7 to No. 14, back to the line above, the

sixty-minute line, to find some equivalent heat contents. For No. 7 the figure for sixty minutes is 232·3 cal./g., and for No. 8 it is 233·8, and so on. It looks as though that slag covering on the No. 15 ingot has kept in the ingot something like 7 or 8 cal./g. and has slowed down the cooling of the ingot to that extent. It seems, therefore, that that ingot would take another ten or thirteen minutes to cool down to the average temperature of about 223. I suggest that if the cooling of a slagged ingot is retarded by that coating of slag, which will keep the heat in, the effect of having no slag on the surface of the ingot is greater than the authors may have expected, or at least it has a very marked effect on the cooling of the ingot. It is the same with the bottom plate, and I feel that the botton plate cannot be ignored.

That brings me to my next point. It is suggested that ingots are still liquid up to a matter of 116 minutes. We have actually tipped ingots of this size on their sides after one hour. We had in mind the turning over which took place when we brought ingots from No. 1 to the mill, and we thought that by laying them on their sides we were getting a displaced pipe, and so increased lamination. We actually tipped a dozen on their sides after one hour after teeming, and to our amazement we did not find any displaced pipe or increased lamination. The suggestion was that our ingots are fairly solid in the middle after one hour. That might well be due to the effect of cooling from the bottom and the cooling from the surface of the ingot. Again, in the cooling from the surface I do not think that we can entirely ignore the FeO-carbon reaction which is taking place, which is an endothermic reaction, and with a vigorous rimming action a tremendous amount of heat must be taken by means of the carbon monoxide from the ingot itself.

A temperature of 1530 deg. Cent. is mentioned as the temperature of the steel in the moulds one minute after teeming was finished. I think it is stated in a later paper that temperatures up to as high as 1550 deg. Cent. have been recorded. I doubt some of those temperatures, because if casting is carried out round about 1580 deg. to 1600 deg. Cent. it seems to me that the cooling effect must bring those temperatures down very quickly. I have never managed to measure a temperature above 1522 deg. Cent. Taking the freezing point by the elements present, and not forgetting that there is some segregation, the carbon is probably 0·8 per cent, and the FeO has gone from 0·1 to 0·25 per cent, while the manganese will be steady about 0·34 to 0·35 per cent. If you take the freezing point just by taking those elements, the temperature of the metal in the mould should, I think, be nearer 1520 deg. Cent. than 1530 deg. Cent. I should also like to ask the authors why they estimate a drop of 30 deg. Cent. in the ladle. If further trials are carried out and the thermo-couples are available, I suggest that the authors should put thermo-couples into the ladle and measure the temperature. It is very interesting to see in Table V that the estimated heat content of all the ingots gives an average figure of 311·4 cal./g. with a standard deviation of 1·46, so that there is a variation there of only ±1 per cent for 95 per cent of the trials. If we look at the heat gained by the slice of the mould or the heat lost by the steel we shall see that the variation is nearer ±20 per cent, and that, of course, will be about 3 or 4 per cent on the actual heat loss. Again, if a 3 to 4 per cent difference is going to make about twenty minutes' difference in stripping time, and it is not possible to measure within closer limits than 3 to 4 per cent, I wonder how much is going to be gained in accuracy in estimating this stripping time.

Sir Charles Goodeve, F.R.S. (Director, British Iron and Steel Research Association) : There is a good deal of practice with ingots in steel works about which I am not at all knowledgeable, but, as I understand it, the works will specify a time—a time of sixty minutes, or whatever it may be—before stripping an ingot, and that time will depend on a formula of one kind or another, such as Mr. Bacon has suggested, or on experience, in relation to the sizes of the ingots. That time has been chosen in order to keep safely away from some critical time below which it is dangerous to lift the ingot by the crane. The authors have translated that time scale into a heat-content scale of the steel ingot, and corresponding to that they have a figure for the heat loss from the molten state, which in one instance they gave as 3½ therms. I am not clear whether it corresponded to the standard value or to a critical heat content below which it was not safe to operate.

I have two questions to put. The first is to the authors. The whole object of their studies has been to reduce the variability about a point so that there is a wide distribution of real values of heat content. It is a different dimension from the time, of course, because it is on a different basis, but one obtains in time a wide range in random distribution of heat contents, and the whole approach of the authors has been to narrow this to a narrower distribution about the same point in the first instance, though they are hoping eventually to slide the whole thing over to the left to get nearer to the critical value than before. My first question, therefore, is to the authors, and it is this : if one did waste a tenth of a therm unnecessarily, what does that correspond to in the soaking pits ? My guess is that it is five times as much—that is, if you lose unnecessarily 0·1 therm per ton of ingot, it will take you five times as many therms in the soaking pit to recover it. That is a very difficult question to ask, because it must depend on all sorts of conditions ; but we ought to have the order of magnitude right, because we do require much more to recover what we have lost. My other question, which I would put to the practical people present here, is this : how often in fact do you have an accident by going too near the critical time or heat content ? Does it happen once a month or once a year in your works, and, when it happens, how serious is it ? Do you kill a man, or just waste an ingot ?

Mr. A. J. K. Honeyman (Steel Company of Wales, Ltd.) : With regard to rimming steel ingots, with bogie casting the critical time is the time of moving the ingot, and in an ordinary open-top rimming cast that is the total time with which we are concerned. Once we can move the ingot, we can strip it and charge it as quickly as we like. On the other hand, a capped ingot can be moved without danger, and then the calculations of the authors are important.

There are some aspects of the matter with which the authors have not dealt, but which I think should be mentioned. One is mould temperature. There are other considerations besides the heating of the ingot ; there is the mould life, and there is the condition of the steel. If the temperature of the mould is too hot, you may as well not dress it at all, and if it is too cold the same thing applies, so that you must have from other considerations a correct mould temperature, which is usually hand warm, or slightly above that. Another consideration, as I say, is the quality of the steel. You may have bunching of casts, with two casts coming to the soaking pit at the same time, and the question as to which is to have priority cannot be decided entirely by the consideration of the authors' calculations. You may have a steel which tends to be a riser, and it is most important that that should be in the soaking pit for the minimum possible time, to prevent troubles with very bad slabs. On the other hand, if you have a killed stabilised steel, a little extra stewing in the soaking pit cannot do any harm. The quality of the steel, therefore, is just as important as the calculations made by the authors.

Mr. A. Jackson (Appleby-Frodingham Steel Company) : We have stripped 10-ton ingots in times down to thirty-seven to forty minutes. I think that if you pick up the mould and lift, and the mould comes off the ingot without the necessity to press on the ingot top, it is obvious that the ingot is sufficiently solid to enable it to strip, and that can happen in forty minutes. If it is not ready to strip and you lower the ram on top of the ingot, and the ram bursts the centre of the top of the ingot, it does not cause an accident which is a danger to life or limb, but it makes a nasty mess.

It must be remembered that if you strip a batch of ingots of our type in forty minutes, it is probably at least two hours before you dare to charge them in the soakers. If you put them straight into the soakers, in five or six hours from tapping they will still balloon when put through the mill, because the inside is still liquid. If, therefore, you strip the ingots quickly to save mould life, you have to let them cool for two hours and put them in soakers for one and a half hours, so that they can be rolled in two and a half to three hours after tapping. You therefore need somewhere to store these ingots. We have always had at Appleby-Frodingham what we call gjers pits—unfired pits—in which we can put three 10-ton ingots. As we tap 300 tons, we strip the first heat quickly, and put it in the gjers pits, and we strip the second one as quickly as possible after that and put that into a gjers pit. We then strip the third one, which is cool enough to charge directly into the soakers. We follow it into the soakers with the second one to be stripped and ultimately put in the first. By that means we can get 12,000 tons per week through rather old-fashioned soakers with a heat consumption which is always under 1,000,000 B.Th.U.

Mr. R. W. Evans (Steel Company of Wales, Ltd.) : I want to try to answer the question put by Sir Charles Goodeve on the frequency with which we get trouble with metal pouring out of an ingot after it has been standing for a short time. In the case of a rimming steel ingot—and I have seen this happen only with a rimming steel ingot—we believe that the mechanism is on these lines. Gas is evolved and passes up the wall of the ingot, and, depending on the thickness of rim required in the finished ingot, if you want to stop it you put a cap on top. When the cap is on, the aim is to get a solid bridge formed at the top, so that the ingot will be completely sealed off and no further gas will come out. From then on you are fighting a battle with the pressure which is building up in the top part of the ingot versus the strength of this cap on top. If the pressure builds up before this is strong enough to resist it, there is an ejection of metal which may or may not be dangerous. As for the frequency of this, I should think that it may happen once a month, or something like that, but in most cases it is not dangerous ; but it has happened that without warning there has been a shoot of metal sprayed out as from a pistol, and this has been

known to travel 30 or 40 yards. If you are passing by when that happens it may be very dangerous.

As evidence of the terrific pressures which are built up, we use our 15-ton bottle-top mould, which is capped on top very quickly. We teem to a certain level shown and we put a very thick cap on, so that very little gas is evolved before we seal the ingot off. When we have done this, we have seen the mould actually rise until there has been 6in of the ingot proud underneath ; the pressure on the top has pushed this 15-ton mould up. That is a measure of the pressure which we are trying to suppress at the top of a rimming steel ingot when we cap it. If we cap it too soon we shall have metal shooting out of the top.

Mr. Savage replied to points raised in the discussion.

(To be continued)

The "Comet"

By C. T. WILKINS. F.R.Ae.S.*

The following abstract is from a paper read by the author to the Royal Institution of Great Britain, London, on November 21, 1952. A brief historical introduction and some concluding paragraphs dealing with manufacture and organisation have been omitted in this abstract, which is concerned with factors influencing the final shape and performance of the "Comet" airliner.

THE exploratory work towards a British jet airliner, which was undertaken with great activity in the latter part of the war and onward, benefited from most helpful and enthusiastic co-operation by the operating interests, notably the British Overseas Airways Corporation and British South American Airways (later absorbed into B.O.A.C.) and by the Ministry of Supply, the National Physical Laboratory, the Ministry of Civil Aviation, gas turbine experts and specialists, and a number of manufacturers of special aircraft components, radio and other equipment quite essential to the aircraft as a whole.

It is fitting that this opportunity be taken to pay a tribute to these many engineers in research and experimental work who contributed in no small measure to the "Comet" as we know it to-day.

de Havilland for its part profited from earlier experience in the design of clean, high-speed aircraft, going back as far as the "D.H.88" racer, which was itself called the "Comet" and which had won the England-Australia Race in October, 1934, beating the first of the highly successful American monoplane transports, the Douglas "D.C.2." In the D.H.91 "Albatross" of 1937 and the wartime D.H.98 "Mosquito" of 1940 this experience had gained force.

At the suggestion of British Overseas Airways Corporation the long-range possibilities of an aircraft to carry six passengers and 1000 lb of mail across the North Atlantic Ocean at very high speed were explored. In the early stages of the study many configurations of aircraft were investigated. Those included a twin-boom layout on the lines of the "Vampire," with three "Goblin" engines in the rear of the fuselage, also a tailless swept wing, various forms of more conventional layout, and even a tail-first arrangement. All of these showed some disadvantage and were abandoned ; furthermore, the de Havilland Company strongly felt that to satisfy a broad market the aircraft would need to carry nearly forty passengers in order to rank competitively as a passenger liner for the trunk routes of the world. The most promising configuration appeared to be a tailless aircraft with a swept-back wing. Little was known about this form of aircraft at the time, but Messerschmitt in Germany had produced and flown a fighter, the "Me 163," of this type.

As de Havilland was interested in exploring this configuration for a fighter as well as for a transport, it was decided to modify a "Vampire" by removing the tail booms and tail, by substituting wings swept at 40 deg. and by providing elevons at the wing tips for control in pitch as well as roll, an orthodox fin and rudder being employed for directional stability and control in yaw. The resultant experimental aircraft, the "D.H.108," provided valuable information for both fighter and transport development, and in the hands of John Derry captured the international 100km closed-circuit record with a speed of 605·23 m.p.h.; with the same pilot it became the first British aircraft to exceed the speed of sound.

This arrangement as applied to the "Comet" showed, amongst other things, that owing to the low lift coefficient of the swept wing, particularly during the landing, aggravated by the elevons and the increase in weight due to the swept wing, the penalty in payload would be in the order of 4000 lb, i.e. 2000 lb for the loss of lift and 2000 lb for the increase in structure weight. The handling characteristics also left much to be desired, particularly during the approach landing. This wing arrangement did, however, show great promise in other directions, particularly with regard to drag reduction at high Mach numbers, giving an increase in speed of about 50 m.p.h., but this was not considered large enough to offset the other disadvantages.

Two things which also were realised at about this time were, first, that since the aircraft was to be ordered in production off the drawing board and was to be operated straight away, any form of aircraft which could not be flown by the average airline pilot was unacceptable ; and secondly, that any aircraft having a restricted purpose, such as the six-seater previously referred to, would be useless.

It was therefore decided to go for an aircraft which was conventional within the limits of the new technique and conception of air travel. This meant that the flying characteristics and such features as take-off and landing speeds, stall behaviour, flight deck layout, cabin size and capacity, &c., would have to be conventional, thus putting out of court any of the more radical conceptions. Thus the "Comet" as we know it to-day emerged. This is not to say that a host of problems did not present themselves for solution. I would like now to deal briefly with some of these.

Choice of Engine.—It may be asked why the "Ghost" engine of the centrifugal flow type was chosen for the "Comet" in preference to the more powerful and efficient axial-flow type, such as the Rolls-Royce "Avon," which is being fitted into the later "Comets."

It was considered, in the first place, that development of the centrifugal type was in a far more advanced stage at that time, and, coupled with the much greater simplicity and robustness of construction, it seemed to be a more suitable engine for civil airline use. Further, it was felt that if the engine and airframe could be designed by the same concern, great benefit would be derived from the close collaboration obtainable during the development stages.

Also it was desired to tap air from the compressor for cabin pressure and heat for the cabin and wing de-icing, and at that time there was no experience in doing this with the axial type compressor. Further, the problem of de-icing the axial engine itself presented a much more difficult problem.

However, all these problems have now been solved with the axial-flow type, but had the axial been chosen at the outset there is no doubt that commercial operation of the "Comet" would have been considerably delayed.

Flying at High Altitude (Pressure Cabin).—Owing to the very high fuel consumption of the jet engine at low altitudes, it is essential that the jet transport fly as high as possible. The optimum height will depend on the weight of the aircraft at any given time, for if the aircraft is flown too high for a given wing loading, the drag will increase due to the high angle of incidence at which it will have to fly. Thus the "Comet" taking off at maximum A.U.W. will climb to about 33,000ft, which it does in about thirty minutes, after which the altitude will be increased as the weight falls off to about 40,000ft during the cruise.

If it is realised that at 40,000ft the pressure of the air is only 2 lb per square inch, and its temperature can be as low as −73 deg. Cent. (this has actually been recorded), and therefore for all practical purposes the air is absolutely dry, the problems of cabin pressurisation, heating and humidification will be appreciated. Under these conditions a failure of the pressure shell might well be catastrophic, and indeed the structural problems in this respect are treated as being in the same category as, say, the wing. In order to keep the cabin altitude at 8000ft, which is considered to be the maximum for passenger travel, a pressure differential of 8¼ lb per square inch is necessary across the pressure shell, windows, doors, &c. This fortunately does not present such a difficult structural problem as was at first supposed, and a surprisingly small increase in weight is necessary over an unpressurised shell even to achieve a safety factor of 2 over the working pressure.

Certain precautions, of course, have to be taken, such as the maintenance of a circular cross section, even around the windscreen structure, inward opening doors and hatches, and a large safety factor (10 in the case of the "Comet") for windows and windscreen.

The problem of the supply of cabin pressure and heat has been very elegantly solved by bleeding air from the main engine compressors, and adequate air supply being available with two or even three engines inoperative. The air from the compressor is sufficiently hot to necessitate the use of air to air heat exchangers to cool it sufficiently before passing it into the cabin. This system eliminates duplicated engine-driven compressors and multiple petrol-burning heaters with their attendant risk of shaft failure and fire.

Very little was known at that time of the conditions of flight in the upper atmosphere, such as wind velocities, turbulence and the effect of low pressure and temperature on the airframe, engines and fuel. In order to explore these conditions a "Vampire" was fitted with a "Ghost" engine, all surplus weight even to the final coat of paint was removed and the span increased from 40ft to 48ft. This aircraft was flown by J. Cunningham in 1948 to an observed altitude of 59,446ft, a world record which still stands.

Drag.—The most fruitful field for the reduction of drag lies in the form of the wing. At moderate Mach numbers—say, up to about $M=0{\cdot}6$, the drag is not much affected by Mach number, but after this the drag begins to rise very steeply. Therefore, either the aeroplane's cruising speed must be kept to a low Mach number, which at the temperatures prevailing at 40,000ft would seriously limit its speed, or steps must be taken to delay the Mach number drag rise. This can be done either by having a thin wing or by sweepback or both. A small wing area also will reduce drag. The "Comet" wing has a thickness/chord ratio of 11 per cent, a sweepback angle of 25 deg. at 25 per cent chord and a wing area of 2015 square feet.

It was necessary to strike a compromise between a thin wing and its attendant high structure weight, a swept wing, also accompanied by high structure weight, the ability to stow the fuel, engine, undercarriage, &c., within the wing profile, and a reasonably low wing loading to give manœuvrability at altitude and an acceptable take-off and landing speed. Fortunately, owing to the large amount of fuel used in flight, the wing loading for landing is much reduced.

The parasite drag was kept low by making the fuselage diameter the minimum required to seat four passengers abreast and placing the engines as much as possible within the wing profile. All the radio aerials are of the flush type, a feature never before achieved in any operational airliner. The windscreen has an unbroken line and does, in fact, conform to the circular sections necessary to carry the high differential pressure loads.

Considerable doubt was expressed in the early days of the degree of visibility which would be obtained through such a windscreen, particularly in rain. To prove this point a mock-up nose and flight deck was fitted to a Horsa glider, which was then towed through rain.

Tare Weight.—Many a potentially good aeroplane has been ruined by excess weight in structure and equipment. A jet airliner is particularly sensitive to this because of the large fuel weight to be carried. In the case of the "Comet" the payload is but 10 per cent of the

* Assistant Chief Designer, the de Havilland Aircraft Company, Ltd.

A.U.W. and the fuel weight is 49 per cent, so it will be seen that, first, fuel consumption is of paramount importance and, secondly, that a slight increase in tare weight can readily produce an aeroplane with negligible payload. The cost to the operator of weight varies from time to time, depending on current conditions, but the latest figure that I have been able to get from British Overseas Airways Corporation is that 1 lb avoirdupois of payload lost or gained is worth no less than £55 sterling per annum per aircraft as passenger load or £38 sterling as freight. It should be realised also that for every pound carried ¼ lb of extra fuel must also be carried. For example, in order to carry a piece of equipment weighing, say, 50 lb the net loss in equivalent payload will be 75 lb.

The converse of this, of course, applies if equipment is left off. Therefore the best way of saving weight is undoubtedly by leaving things off, so that great care must be taken to see that no unnecessary equipment or structure is carried and that all dimensions are as small as possible, such as fuselage length and diameter.

In one way the jet aircraft is particularly good in this respect, as apart from the deletion of the airscrew itself with its attendant weight and complication, the undercarriage height and therefore its weight is kept small. This incidentally produces an aircraft which is low on the ground, which in turn makes for ease of maintenance and servicing, reducing the use of steps and gantries to a minimum.

Fuel Storage.—The storage of fuel presents one of the major problems in the design of a jet airliner. It will readily be seen that to get 7000 Imperial gallons of fuel into an aircraft of 115 ft span with a thin wing is not easy, as it must all be stowed in the wings, since it is not acceptable to carry fuel in the fuselage for obvious reasons, but mainly due to fire risk. The fuel should be carried as far out along the span as possible to reduce the bending moment of the wing, and this, in turn, owing to the wing sweep, brings in problems of centre of gravity and the order of fuel usage then becomes important.

With the vast quantity of fuel to be uplifted underwing pressure refuelling is essential if turn-around times are to be kept down. In the "Comet" the whole of the 7000 gallons can be uplifted in twenty minutes, using one refueller on each side of the aircraft. In order to save space tanks built integral with the wing structure must be used. These present no mean problem owing to structural deformation and the high permeability of kerosene. In this connection the use of metal-to-metal bonding in place of riveting shows a big advantage, besides giving a more efficient structure, and this method of joining is used extensively throughout the "Comet."

Fire Risk.—Owing to the necessity for burying the engines in the wing and the large amount of fuel carried, fire precautions must be taken very seriously, particularly if relighting of the engines is to be undertaken in the air, this despite the greatly increased safety of kerosene over petrol, a feature which cannot be too strongly emphasised. All engine compartments into which fuel might find its way must be adequatey drained and vented, and adjacent engines and tail pipes must be sealed off from each other, to avoid the possibility of the running engine setting fire to any fuel emerging from the engine to be started, particularly in the case of a wet start.

In the case of a crash landing, unlike propeller driving engines, the engine will not be stopped by the propeller, and so special precautions must be taken. At the lowest point of the aircraft which, with the undercarriage retracted, makes the first contact with the ground, a device is provided which automatically turns off the high-pressure fuel supply to the engine, sets off the fire extinguisher bottles and after four seconds delay turns off all the electrical services, with the exception of the emergency lighting. Undoubtedly, one of the most important factors in combating a fire in the air is instantaneous and reliable detection, for if the high-pressure fuel supply to the engine is cut off immediately, it is most likely that the fire will be blown out by the large quantity of air passing through the engine, and it may not even be necessary to operate the fire extinguishing system.

Controls.—Because of the wide range of air speed, Mach number and altitude of the jet airliner, the effective lightening of control surface operation presents a very difficult problem.

For an aircraft of the size of the "Comet" aerodynamically balanced controls are certainly a practical proposition, but past experience has shown that the flight time taken to get these to an acceptable standard is prohibitive. Many hours of test flying are necessary, which is a very costly business in itself, and further, during this time no other useful tests can be undertaken until the controls are right. It is possible, however, using power-operated controls, to reproduce on the ground, exactly the conditions prevailing in flight. It was decided, therefore, to provide full power operation for all flying controls in the "Comet."

The question of manual control in the event of power failure was carefully considered, but the difficulty of providing such a control, which would be acceptable to the average airline pilot, was too great and would present almost as difficult a problem as full aerodynamically balanced controls. A fully duplicated power control system would, however, provide precisely the same feel to the pilot whether the main or the emergency system was being used, thus overcoming this criticism. A system providing two entirely independent power units for each control was therefore adopted.

Noise.—One of the great unknowns in the jet airliner was the nature and extent of the noise which would be experienced by the passengers. Although many flights had been made with jet engines, these were usually placed behind the pilot and, as such, were not representative of the "Comet," whose engines are mounted close to the cabin. This placing of the engine close to the centre line of the aircraft prevents swing due to engine failure, and means that a smaller fin and rudder can be used. However, after a flight in a Vickers "Viking" fitted with two Rolls-Royce "Nene" engines, it was realised that the noise problem had to be taken seriously, particularly with regard to impeller whine at the front and the jet roar at the rear.

In order to check this a "Ghost" engine was mounted alongside a test specimen of the fuselage on the ground and the noise assessed. This appeared to be fairly alarming, but as it represented take-off conditions it did not really give an indication of conditions during the cruise. One point of interest emerged from this test; that was, that although the jet stream emerges at an included angle of about 14 deg., the highest noise intensity lies in an included angle of about 90 deg., and that within this angle very severe local vibration induced by the noise can be set up in any structure which is too close to the jet orifice and is insufficiently stiff.

It was found necessary, therefore, to place the passengers as far forward of the jet orifice as possible, leaving the rear of the fuselage for the washrooms, wardrobes and vestibule, and any other infrequently inhabited parts of the aircraft. Fortunately, the impression given by the "Nene Viking" was misleading: first, because the cabin was not pressurised and therefore not perfectly sealed; and secondly, because the aeroplane did not fly at high altitude. Although the "Ghost" engine delivers 5000 lb of static thrust for take-off, under cruising conditions at 40,000ft the thrust has fallen off to something like 1300 lb per engine.

Since the noise produced is roughly in proportion to the thrust delivered, and coupled with the fact that the cabin is completely sealed and adequately soundproofed, and also that the indicated airspeed is low at altitude although the true A.S. may be higher and therefore the wind noises over the aircraft are low, it will be appreciated that the noise level under cruising conditions, which after all is what really matters, will be very low.

De-icing.—The formation of ice on aircraft is a well-known phenomenon and presents, in general, similar problems on jet aircraft as on the more conventional types. The absence of airscrews and carburettor is a relief in this respect, the main difference in the problem being the engine air intakes and engine itself.

Owing to its high rate of climb the jet aircraft does not spend much time in icing conditions on the climb, but on descent, and under stand-off conditions it may well remain in these conditions for as long a time as any other aircraft. The obvious method of de-icing the leading edges of the wings, tail and engine intakes is by hot air, which is readily available in sufficient quantities directly from the engine compressors. This presents no great difficulty except in the case of the engine air intakes, where precautions must be taken to avoid large lumps of ice coming away from the lips of the intakes and damaging the impeller. The centrifugal type of impeller is considerably more robust than the axial type and shows some advantage in this respect. Care must also be taken to ensure that the engine revolutions do not drop to too low a level in icing conditions, or ice will form on the impeller blades, causing rough running of the engine; but if the engine revolutions are kept reasonably high this will be continuously thrown off and absorbed in the engine.

Ordering.—The general conception of the "Comet" having been determined, an order had to be placed for its building. The accepted method of doing this, at that time, was for the operator, in this case British Overseas Airways Corporation, to indicate to the Ministry of Civil Aviation that they wanted the aeroplane, after which the Ministry of Civil Aviation would request the Ministry of Supply to place an order for two prototypes with the constructor. After these had been built and tested a production order would then be placed. The de Havilland Company realised that if the then current method were adopted, the whole project would take about seven years or more to complete.

The company therefore asked for a production order straight away for fourteen aircraft, in addition to the two development aircraft. This British Overseas Airways Corporation and British South American Airways were courageous enough to give, provided the company would guarantee minimum performance figures, delivery dates and price. It was on this basis that the project was undertaken, and I am convinced that at least two years were saved in getting the aircraft into operational service by the elimination of the prototype stage. The de Havilland Company estimated that it would be necessary to sell nearly fifty "Comets" in order to break even on the investment, and although the starting orders amounted to only sixteen aircraft, the company was sufficiently confident of being able to sell a further thirty to consider the project as a worthwhile risk. It is in fact the greatest venture that the company has made.

Turbo-Electric Ship "Maori"

THURSDAY of last week was a Royal occasion at the Walker Naval Yard of Vickers-Armstrongs, Ltd., when the T.E.V. "Maori" was named and launched by H.R.H. Princess Margaret. The "Maori," which is being built for the Union Steam Ship Company of New Zealand, Ltd., is a larger and more modern version of the "Hinemoa," delivered to the company in 1946 by the builders of the new ship. When completed, she will sail in the ferry service connecting the two main islands through the ports of Wellington and Lyttleton. The ship has been designed to have a well-balanced profile with a raked funnel and single mast, and the principal particulars are: length between perpendiculars, 425ft; breadth moulded, 63ft; depth moulded, 29ft; displacement, approximately 7260 tons and a gross tonnage of 8000. A total of 968 passengers will be carried on four decks, in addition to the boat deck, in one, two, three and four-berth cabins, and a café and smoke room are arranged on the promenade deck. Subdivision of the hull is effected by eleven watertight bulkheads, and general cargo is four holds and the lower 'tween decks. The ship is powered by B.T.H. turbo-electric machinery, driving twin screws and developing 13,000 s.h.p. to give a speed of 21 knots. For propulsion there are two synchronous motors, each having a maximum rating of 6500 s.h.p. at 220 r.p.m. and supplied with current from two three-phase alternators with an output of 5120kW at 3080 r.p.m. Each alternator is driven by B.T.H. multi-stage impulse turbines taking steam at 425 lb per square inch and 725 deg. Fah.

Instruction and Research in Hydraulic Laboratories

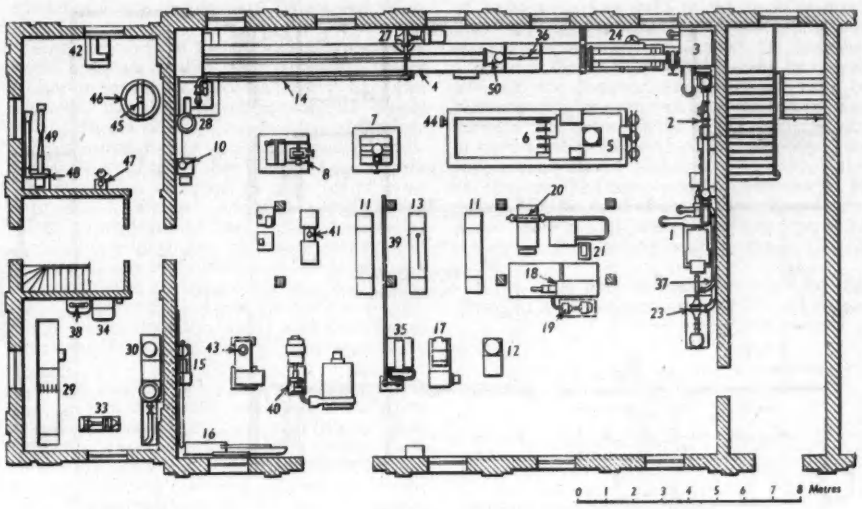
By HERBERT ADDISON, O.B.E., M.Sc., M.I.Mech.E.

In this paper, presented before the Institution of Mechanical Engineers on November 28th, and here abstracted, the Institution chosen for study is the Faculty of Engineering of the Fouad I University, Giza, Egypt, where, twice within the space of thirty years, the staff have had the opportunity of planning completely new hydraulic laboratories. Some units of experimental equipment are described, and comments are added giving the results of experience in the conduct of the laboratories. To show the relationship between instruction and research in such an institution, the findings of some post-graduate research projects carried out there are summarised.

A CONSEQUENCE of the adaptability of liquids for experimental purposes is that no two instructional hydraulic laboratories seem to be alike. A traveller who visited such laboratories in Great Britain, in continental Europe, in America, and in the British Commonwealth would find it hard to use them as a foundation on which to construct a unique composite or eclectic plan for the best possible hydraulics laboratory. There is an additional reason for this difficulty: the hydraulics laboratory, like the institution of which it forms a part, is governed by particular local requirements and conditions; and, unless these were fully understood, the visitor could not properly appreciate what lay before him.

If, then, any prefabricated plan might be untrustworthy, yet guidance might be extracted from a study of developments during a term of years at one particular institution. By showing how policies and equipment responded to changing local conditions, such a record could give an indication, at least, of how to assess possibilities elsewhere. It is in this hope that the following notes are presented. They relate to the author's own experience during thirty years at a technological institution in Egypt. Although, in conformity with political changes and with the general advance of secular education in Egypt, this institution bore the titles in turn of Royal School of Engineering, Faculty of Engineering of the Egyptian University, and Faculty of Engineering of the Fouad I University, its status was never in doubt. For the greater part of the period under review—1921–51—the School was the only institution in the country for the training of professional engineers, and when satellite institutions were created it still remained the most influential among them.

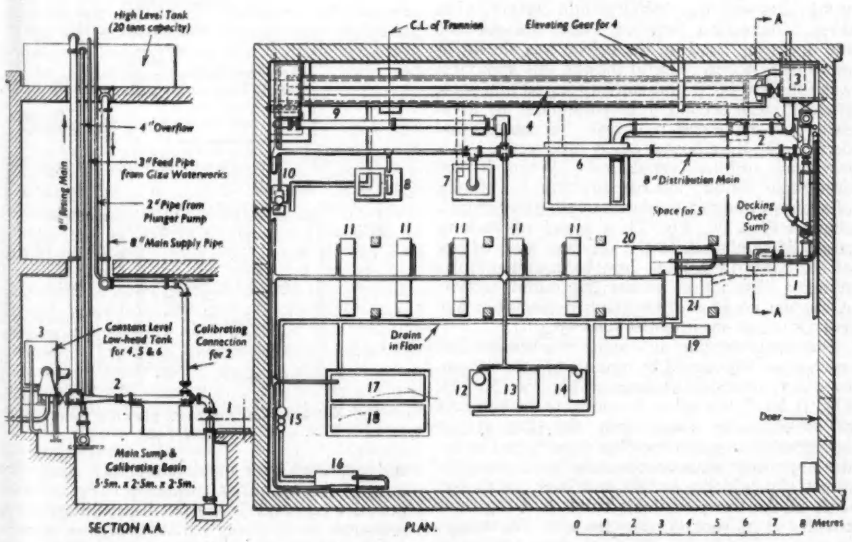
When, in 1903, the first school buildings were erected on the existing site at Giza, about 2 miles south-west of Cairo, few young Egyptians were attracted to the profession of engineering. But before long the development of secondary education in the country augmented the number of candidates for technological training; and, in due time, the number on the rolls of the School of Engineering began to respond. By the end of the academic year 1921–22, there were 500 students (Anon. 1922). The original accommodation was therefore no longer adequate; furthermore, progress in equipping the laboratories at Giza had been retarded by the 1914–18 war, as it had elsewhere. Accordingly, the construction of a new block of buildings was sanctioned in 1923, in which provision was made for a new hydraulics laboratory.



See also Legend of Fig. 1

13. Laminar flow.
17. High-pressure high-speed hydraulic oil pump.
18. 1/100 scale model of under-sluice.
23. 3in three-stage centrifugal pump (service and experiments).
24. 8in propeller pump.
27. 4in to 5in pump (service only).
28. Orifice and tail pipe.
29. 1/50 scale model of canal regulator.
30. Forced vortex motion.
33. Screw pump (service and experiments).
34. Pressure surges in pipe.
35. Gear wheel pump for oil.
36. Dynamic thrust on immersed solids.
37. Demonstration of cavitation.
38. Small closed-circuit water tunnel.
39. Oil flow in pipes fed by 35.
40. 4in to 3in self-priming pump.
41. Open circuit water tunnel.
42. Visual-flow centrifugal pump.
43. Pressure distribution in pump impeller.
44. Indicating, recording and integrating flow meter.
45. Ten-stage submersible bore-hole pump, drawing from circular well 46.
46. Circular well.
47. Electro-hydraulic thrustor.
48. Centrifugal fan, discharging into ducting 49.
49. Ducting.
50. Elbow draught tube for turbine.

Fig. 2—Equipment of 1926 Laboratory in 1951


High Level Tank (20 tons capacity)
4" Overflow
3" Feed Pipe from Giza Waterworks
2" Pipe from Plunger Pump
8" Main Supply Pipe
8" Rising Main
Constant Level Low-head Tank for 4, 5 & 6
Calibrating Connection for 2
Main Sump & Calibrating Basin 5·5m. x 2·5m. x 2·5m.
SECTION A.A.
C.L. of Trunnion
Elevating Gear for 4
8" Distribution Main
Space for 5
Decking Over Sump
Drains in Floor
Door
PLAN.
0 1 2 3 4 5 6 7 8 Metres

1. 8in centrifugal pump.
2. 8in Venturi meter.
3. Low-head tank.
4. Experimental channel.
6. Channel for sluice model tests.
7. Inward-flow turbine.
8. Pelton wheel.
9. 8in circular channel.
10. Hydraulic ram.
11. Tanks for weir and orifice flow.
12. Dynamic thrust of jets.
13. Critical velocity.
14. Flow through sand.
15. Friction in pipes.
16. Hydraulic gradient.
17. Archimedean screw.
18. Water wheel.
19. 2in centrifugal pump.
20. Plunger pump.
21. Lea discharge recorder.

Fig. 1—Original Projected Layout for 1926 Laboratory

THE 1926 HYDRAULICS LABORATORY

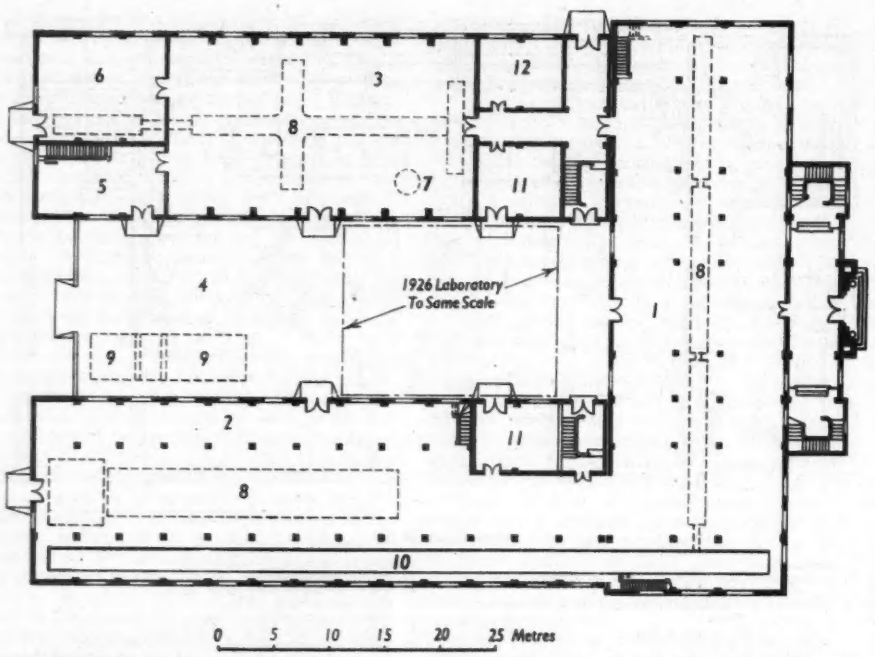
Within the limits allotted—20m by 15m—it was proposed to set out the experimental equipment on the lines shown in Fig. 1; the building itself was arranged to suit, and when the first class of students was admitted in December, 1926, they found the layout substantially as was originally intended. Four years later, as a result of the improvements and additions that experience had shown to be necessary, the arrangement of the south end of the laboratory was altered. Before long, more floor space became necessary, not only to accommodate the increasing number of students, but also to make room for the new apparatus that might raise the level of instruction. An adjacent room to the north-west was in this way brought into use in 1938, and a companion room to the north-east was ready for occupation in 1951.

By this time the layout of the combined laboratories had reached the stage shown in Fig. 2. No further expansion on the original site was henceforth practicable; yet still the scope and equipment of the hydraulics department lagged behind the needs of the Faculty. Of the 1800 undergraduates now enrolled, more than 300 attended the hydraulics laboratory each week. As compared with the 1926 School of Engineering which comprised departments of civil, mechanical, and electrical engineering, the Faculty now embraced also departments of chemical and of mining engineering, and the nucleus of a department of aeronautical engineering. Graduates could hope to find in their own country appointments as engineers for carrying out diverse duties, or there was increasing scope for academic work in the Fouad I University or in other universities.

If instructional needs had expanded to such an extent within the space of twenty-five years, there had been a still more insistent call for research facilities. By reason of its enhanced academic status, the Faculty of Engineering now directly encouraged post-graduate research conducted by members of its own staff. It welcomed investigators from outside organisations or even from other countries, and it was prepared to undertake commercial testing, which implied that the hydraulics laboratory might be called upon to give certified reports upon pumps, meters, and the like.

Considerations such as these indicated that it

* Late Professor of Hydraulic Machines, Faculty of Engineering, Fouad I University, Giza, Egypt.



1. Main South Laboratory.
2. Main West Laboratory.
3. Main East Laboratory.
4. Courtyard.
5. Workshop (metal work below woodwork above).
6. Pump chamber.
7. Suction pit, 11m deep, 2m in diameter.
8. Underground storage reservoirs (250 tons capacity in each, laboratory).
9. Calibrating basins.
10. Open channel, 66m by 2m by 2m.
11. Store rooms.
12. Switch chamber, for incoming electricity supply (110V d.c., and 220V, three-phase, 50 c/s).

Fig. 3—Ground-Floor Plan, Department of Fluid Mechanics and Hydraulic Engineering

was not merely an enlarged hydraulics laboratory that the Faculty required, but a new autonomous department with its own organisation and its own buildings : it would be entitled the Department of Fluid Mechanics and Hydraulic Engineering.

The Department of Fluid Mechanics and Hydraulic Engineering

It is not to be imagined that the tutorial staff were caught unawares by these developments. Even before the 1939–45 war they had sketched out various projects for new buildings which would include improved hydraulics laboratories : a final scheme was approved in 1947, construction was begun early in 1951, and the complete building was handed over to the Faculty in the summer of 1952. As the ground plan in Fig. 3 shows, three main laboratories enclose an open courtyard. The south laboratory that forms the base of the " U " measures 49m by 15m and is provisionally allocated for general undergraduate instruction in fluid mechanics and hydraulics. The west laboratory (40m by 15m) is specifically arranged for civil engineering or river-flow or open-channel hydraulics, while the east laboratory (27m by 15m) will be devoted to hydraulic machinery or mechanical engineering hydraulics.

At mezzanine floor-level there are galleries overlooking the south and west laboratories, and also staff rooms, tutorial class rooms, &c. On the main first floor there are a large lecture room, drawing-offices, a departmental library and reading room, and other staff rooms.

Apparatus to Suit the Needs of the Class

If no clear line of policy can be discerned in this brief review of developments at Giza, that need not imply that the tutorial staff were unconscious of particular local requirements. They had to remember, first, that the language of instruction, English, was not the same as the native language of the students, Arabic ; and, secondly, that the students had not as yet that long tradition of mechanical knowledge and aptitude that supported their fellows in Western Europe and America. Each item of experimental apparatus, therefore, should be specially devised to show in the simplest and most vivid way the particular fundamental law or relation concerned, and this implied, for example, that the relative importance of laboratory work as compared with lecture hours was even higher than in England. In course of time the tutors could locate and could try to illuminate some particular " blind spot " that afflicted a class—some refractory principle that no amount of oral explanation seemed to be able to make clear. An example of one such attempt is shown in Fig. 4. The purpose of this apparatus was to let a group of students see how a draught tube worked (No. 28, Fig. 2). They would first measure the flow through a bell-mouthed orifice ; next, they could observe how the flow would increase by the screwing on to the orifice of a parallel tail pipe. Finally, a diverging tail pipe would augment the discharge still further. The direct connection between these changes and the operating head on the orifice was shown by piezometer tubes. Useful though this apparatus was found to be, it gradually appeared that some students still needed a helping hand to assist them over the next step, namely, the changes that occurred in an elbow draught tube as used in a low-head turbine installation. When it was eventually found possible to mount a model of such a draught tube in the main experimental channel (No. 50, Fig. 2), a group of students could be reminded, in the bluntest way, of one of the basic difficulties—how to ensure uniform velocity distribution across the outlet section. A student could put his hand in the water and feel the variations in outlet velocity.

Simplicity verging on crudity marked another mechanism that could be mounted in the laboratory's experimental channel. This one (No. 36, Fig. 2) was intended to demonstrate the influence of velocity and shape upon the drag on an immersed solid. Shown schematically in Fig. 5*a*, the apparatus allowed the drag to be assessed directly by a jockey weight and lever ; although each of the three available solids had the same circular cross section, the one with the streamlined shape manifestly offered the least resistance. Types of pressure distribution could be studied in the simple water tunnel shown in Fig. 5*b*. It was one of those pieces of apparatus that are equally useful for demonstration or for quantitative experiment, and that take full advantage of the properties of water as a medium. It stood always in readiness ; the water levels in the piezometer tubes responded obediently to the movements of the regulating valve, and the general nature of the pressure distribution could not be misunderstood. A group of students wishing to make the best use of a two-hour laboratory period could record the heights of the water columns relating to an aerofoil—or perhaps hydrofoil—section, they could plot the pressure at the corresponding points, and finally extract a good estimate of the lift and drag on the hydrofoil. Other groups might repeat the experiment, using a different angle of attack, thereby collecting material wherewith the whole class could plot the relations between angle of attack, and lift and drag coefficients.

In the third apparatus of this particular series there was no provision for measurement, and no question could arise about the wisdom of encouraging numerical observations that might so easily be vitiated by gross experimental errors. Here the working section of a little closed-circuit water tunnel had transparent windows ; the flow patterns around objects inserted in this section could be made visible by mixing sawdust in the water. If desired, an optical lantern could be used to project the pattern on to a screen (Thomson, 1952).

Principles of Roto-Dynamic Machinery

Comparison between the original and the present state of the 1926 laboratory, as shown in Figs. 1 and 2, shows a significant trend ; hydraulic machinery is increasing its relative importance. This trend accurately reflects national changes and their influence upon opinion within the college. During the first twenty-five years of the laboratory's life, industrialisation in Egypt had been vigorously stimulated and had not escaped the notice of young men in search of a career. Only three of such young men gained the Diploma of Mechanical Engineering at Giza in the session 1933–34, whereas in 1951 the corresponding number was about eighty. Yet did the diversity of hydraulic energy converters represented in the present laboratory of itself guarantee an understanding of the basic principles involved ? The tutorial staff had no such confidence. They therefore designed and installed the apparatus shown in Fig. 6 (No. 30, Fig. 2). A vertical-spindle electric motor drives a rotor whose radial blades

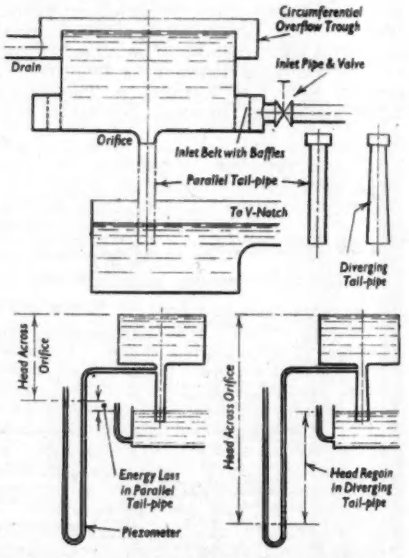


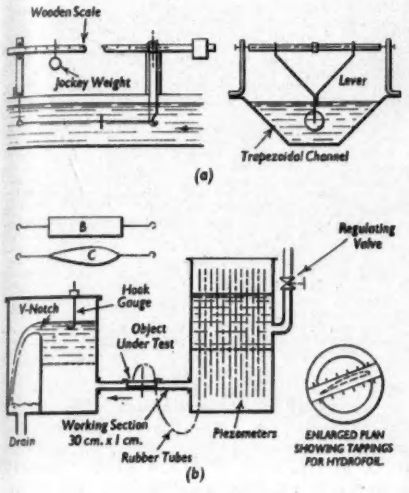
Fig. 4—Apparatus for Demonstrating Effect of a Draught Tube

are separated by a small clearance from the flat base of the cylindrical container. By means of pressure tappings in the flat base, differences in pressure head generated in the rotor can be indicated in a bank of piezometers. Here again was a successful dual-purpose apparatus. Used for demonstration, it showed how pressure differences build up as rotational speed rises, just as they do in any roto-dynamic pump ; used for quantitative work, it enabled a group of students to plot the paraboloidal pressure distribution established within a forced vortex.

In due time a more complex problem yielded to study : how to show the variations in pressure along a circumferential path when water flows through a rotor, and, thereby, to go to the root of a whole range of problems of energy transfer. This apparatus took the form shown in Fig. 7 (No. 43, Fig. 2). The rotor—now a true impeller

—was built up so that all its surfaces could be machined ; each of the five pressure holes communicated by a port with its own groove in a rotating distributor projecting axially downwards. From corresponding fixed grooves in the lower cover of the apparatus, pressure could be conducted by external pipes to a bank of five piezometer columns. For regulating the flow of liquid in the main closed external circuit—either water or thin oil—there was a throttle valve ; for measuring the flow there was an orifice meter, Fig. 8.

When the complete apparatus had been brought to the point where it was fit for demonstration to groups of students, it was found to be just as convenient as the earlier forced-vortex apparatus. The class observing the gauge-tubes had learned by analysis that the differential-head across a rotor blade was likely



a Comparison between disc, cylinder *B* and streamlined solid *C*, all of 10 cm diameter.
b Water tunnel for experiments on hydrofoil, &c.

Fig. 5—Apparatus for Demonstrating Thrust and Pressure Distribution on Solids

to vary directly as (1) the rate of discharge through the rotor ; (2) the speed of rotation. When the demonstrator opened the regulating valve or increased the motor speed, the indicating columns responded immediately : they did exactly what was expected of them.

Tutorial Experience in the 1926 Laboratory

The wealth of equipment in itself (in the 1926 laboratory) was not found to be burdensome. On the contrary, it enabled the classes to develop a more corporate sense of their laboratory work. They could reduce by stages the time spent in making routine observations until it was just long enough to show the value of the particular technique involved : this left better opportunities in the subsequent tutorial discussion for comparing the results of individual groups. If each of a group of undergraduates studied the hydraulic properties of one of a range of brass pipes of graded diameters, then their communal efforts could be reflected in the graph in which all the values of pipe-friction coefficient were plotted against Reynolds number. Similarly, although no individual experimenter might find time to plot the head-discharge characteristic for each of the half-dozen roto-dynamic pumps in the laboratory, yet if all the groups were to pool their results by plotting them on a common non-dimensional basis, they would all see a comprehensive picture of their work.

Hydraulic Research at Giza : 1920–35

Even before the 1926 laboratory was projected, the School of Engineering had been associated with noteworthy researches in the field of hydraulic engineering. These concerned the discharge of scale models of the sluices of the Assuan dam : conducted in the school grounds under the direction of Dr. H. E. Hurst, the Director-General of the Physical Department of the Egyptian Ministry of Public Works, they formed a valuable link in establishing the reliability of scale-model tests (Hurst and Watt, 1923–24).

When members of the school staff themselves began research in the new laboratory, using apparatus for which space had previously been allocated, they likewise chose subjects closely allied with the needs of the country. Efficiency and performance tests on an Archimedean screw were well rewarded : they increased the respect that should be accorded to a device with so illustrious a lineage (Addison, 1929). They helped to explain why the Archimedean screw is still very popular for small-scale irrigation in Egypt, and why in the Netherlands it is returning to service even for large-scale drainage operations. Experimental studies on the flow through model sluices (Addison, 1931) were intended to supplement the work in this field already on record.

Before these investigations were completed it had become clear that more space would be needed for research. Fortunately, at that moment a small building in the adjacent courtyard at the school fell vacant : it was equipped as an irrigation research laboratory, where various investigations on free-flow hydraulics were later carried out (Addison, 1938 ; Shukri, 1949–50).

In the meantime, a change in the status of the School of Engineering called for a revised attitude towards hydraulic research. By reason of its incorporation in the Egyptian University in 1935, the new Faculty of Engineering could now directly encourage research among its junior staff : it could recommend the grant of higher degrees which would qualify the recipients for academic posts in the University or elsewhere.

Hydraulic Research—1935–51

Without claiming that any long-term programme was forthwith inaugurated, it can at least be said that some of the various post-graduate research projects that the exigencies of undergraduate instruction permitted did in course of time shape themselves into a recognisable pattern—at least in the field of hydraulic machinery. They had the common aim of elucidating in increasing detail the flow conditions when a liquid traverses the passages of a roto-dynamic pump. The first experimenter in this team

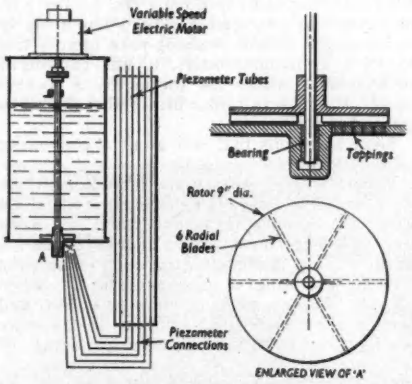


Fig. 6—Apparatus for Demonstrating Pressure Distribution in Forced Vortex

confined himself to the fixed or stationary passages of a centrifugal pump and a screw pump ; and certainly he was constrained by no questions of policy. In the first place, he simply wanted to know what happened inside a particular pump that behaved unaccountably. To describe what he had found this investigator evolved a system of building-to-scale three-dimensional models which could afterwards be photographed (Addison and Sadek, 1948).

Advancing now to the next phase of the inquiry—the conditions within rotating passages—another candidate for the Master of Engineering degree was able to use the instructional apparatus illustrated in Fig. 7, which thereby gained the distinction of being equally suitable for demonstration, for undergraduate experiment, and for post-graduate research. For this additional duty, the selector plate between impeller and distributor was brought into action. It had ports in its upper surface registering with rows of holes at various radii in the impeller disc ; thus by giving the selector plate the appropriate angular displacement relative to the impeller, any one of the six rows of holes could be chosen and put into communication with the bank of piezometer tubes. In this way the entire area between the rotor blades could be explored, in both a radial-bladed impeller and an impeller with typical curved blades, Fig. 9. When this experimenter had completed his observations, he found, like his predecessor, that a three-dimensional scale model offered the best means of stating a three-dimensional problem (Sayed, 1949).

What other lines of approach could be suggested to a third experimenter ? Could he not

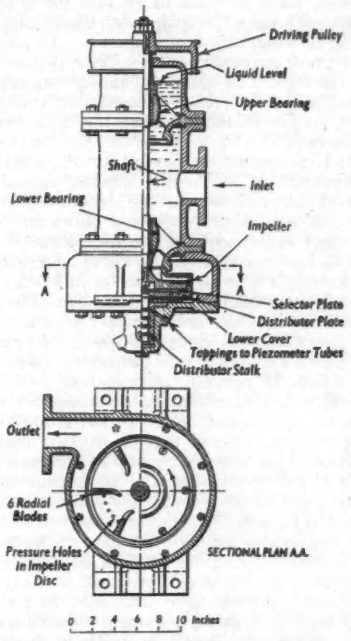


Fig. 7—Apparatus for Investigating Pressure Distribution in Centrifugal Pump Rotor

pursue, in the field of roto-dynamic machinery, one of the main aims of the laboratory, namely, that of making the behaviour of liquids visible ? To do so effectively would require an outfit comprising a closed circuit and including a pump with transparent sides. Then if the system were to be charged with water carrying sawdust in suspension, the observer might be able to watch the water on its way through both the moving and the stationary passages. When, after various vicissitudes, such an apparatus was set to work, its performance was in one respect disappointing. No matter how intently the experimenter examined the transparent rotating impeller, whether directly or through a stroboscope, he could find no formal flow pattern : he could not trace the absolute path of the liquid elements. Yet this failure was only a comparative one. Did it not indeed agree with the findings of earlier experiments ? If the *relative* velocity varied across the impeller passages was it likely that the *absolute* velocities would be so uniform that all liquid elements would follow a common path ?

On the other hand, the observed behaviour of the liquid in the pump diffuser accorded quite well with predictions.

At this stage the third investigator did not relax his interest in the absolute path of the liquid : even if he could not say he had traced the water moving along that path, he could compel the water to follow what he believed to be the absolute path. To do so he removed from a normal type of double-entry centrifugal pump its own impeller, and inserted in its place a set of dummy or stationary vanes, shaped to the curvature of the assumed absolute path ; then he allowed water to flow through the apparatus—no longer worthy to be called a pump—at the prescribed rate. (Fawzi, 1951).

A fourth candidate for the Master of Engineering degree took as his subject of study, the

behaviour of self-priming centrifugal pumps. His results give useful guidance in choosing a self-priming pump for a particular kind of duty (Sami, 1950).

Equipment and Organisation : Some General Conclusions

Experience at Giza during more than twenty-five years had given the staff fairly clear views on how future hydraulic laboratories should be conducted. Some of these views have already been expressed in this paper : others will now be summarised. Although they all relate to one particular locality, they may perhaps be usefully compared with what has been found desirable elsewhere.

(1) If the size of the technological institution permits, there is much to be said for granting independence to the hydraulics laboratory and to the activities that centre upon it. To put this work under the control either of the civil engineering department or of the mechanical engineering department may create difficulties in maintaining a proper balance between the requirements of the two.

(2) Experiments on flowing liquids, and even demonstrations of flowing liquids, should, in general, be confined to the laboratory itself. It requires a disproportionate effort to make any such experiments visible to a class of fifty or 100 students in a lecture room ; moreover, the lecturer's time is likely to be fully occupied in analytical explanations and the like. The projection lantern, the epidiascope and illustrative models of various kinds give plenty of chances of introducing variety into the lecture course.

(3) For the reasons just mentioned, it is all the more important that in the laboratory itself generous floor space should be left around each piece of apparatus, so that its working may be explained to a fair-sized group of students.

(4) If the various items of equipment are to be arranged to conform to any plan or pattern, it should be a flexible rather than a rigid one. For this reason the floors of the new hydraulic engineering laboratories at Giza have been left completely flush and unobstructed, without any permanent concrete tanks, channels, &c., above floor level such as were thought suitable in the 1926 laboratory. Provision has been made for installing cranes or runways which will encourage the rearrangement of apparatus whenever this seems advantageous.

(5) Service pumps, installed solely for lifting water from the underground reservoirs to constant-level overhead tanks, should be distinct

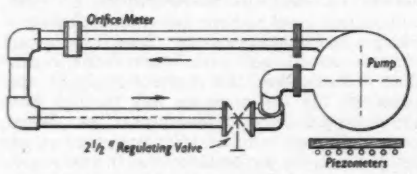


Fig. 8—Plan of Flow Circuit for Pressure Distribution Apparatus, Fig. 7

from the experimental pumps used by students. At Giza there will in future be three separate systems, giving static heads above floor level of 3·5m, 9m and 16m, respectively.

(6) The main bus pipes or the overhead network through which water from the constant-level tanks is distributed to individual experimental units should be of generous cross-section ; this will ensure that regulation of the flow to one unit will not sensibly disturb the unvarying discharge that students working on adjacent units are trying to secure.

(7) For measuring the discharge in free-flow apparatus, portable weir-gauging tanks are proposed, having hook-gauges for determination of head. In closed systems, the helical type of inferential meter has often been preferred, because it occupies little space, is not unduly sensitive to conditions of installation, and permits readings to be taken fairly quickly. But calibration is essential (Addison, 1942). Recent experience has shown the valuable possibilities of the rotameter : its instant and visible response to flow variations is most attractive. But quite apart from the advantages of a particular flow meter for a particular piece of apparatus, the over-riding need is to see that the laboratory houses the widest variety of measuring equipment, so that the students themselves can make pertinent comparisons.

(8) For calibrating purposes the main underground reservoir of the 1926 laboratory could be used only when other work had virtually ceased. Independent calibrating basins are therefore provided for the new laboratories ; set beneath floor level in the open courtyard, one has a capacity of 40 tons and the other 80 tons. Intended to be completely watertight, with no

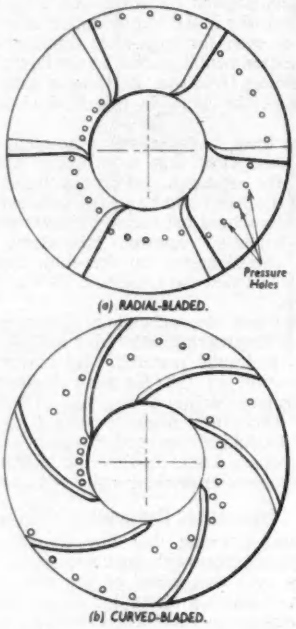


Fig. 9—Spacing of Pressure Holes in Disc of Impeller

outlets below top water-level, they can be emptied only by pumps, and can receive water from either the east or west laboratory.

(9) For measuring the power transmitted from electric motors to pumps, the Amsler type of torque dynamometer has been found highly satisfactory. Where swinging-yoke motors had to serve as dynamometers, it was considered preferable to assess the torque by a jockey-weight, sliding on a torque arm, rather than by a spring-balance.

Some questions that still await a convincing solution include :—

(10) In a large instructional laboratory where many students are working, the noise of falling water can be quite tiresome ; moreover, when water falls freely it entrains air in disadvantageous amounts. Yet if attempts are made to silence the flow by enclosing it in some form of closed passage, the advantage of visibility is lost, and there is the danger that variations in tail-water conditions may themselves disturb the rate of discharge.

(11) Perhaps due to insufficient experience, no wholly satisfactory system of electric-motor speed-control has yet been found, applicable to a variety of motors of outputs ranging from, perhaps, ½ h.p. to 40 h.p. This is a matter of considerable moment when experimenting on roto-dynamic pumps, where a speed range over a ratio of 3/1 is desirable, with the possibility of holding the speed steady within less than ½ per cent of a stipulated value. Commercial control panels as supplied with d.c. motors give a speed range that is too restricted, and a speed adjustment that is too coarse. Commutator-type a.c. motors might fulfil the conditions, but they appear to be very expensive and they might not be adaptable for use as swinging-yoke dynamometers. As for Ward Leonard sets applied to d.c. motors, the combination was doubtless admirable for one large motor, but could it be recommended for a number of independent small ones ?

(12) Commercial sluice-valves were not altogether suitable for the close regulation of water flow ; the spindles usually had too much backlash and the mechanism was not sufficiently positive. With the intention of ensuring that a given setting of the hand-wheel would give an invariable discharge under a steady head, special valves had been built to the Faculty's specifications ; but in practice they were only partially successful.

(13) It would be highly instructive if students could themselves record and measure high-frequency pressure fluctuations in hydraulic apparatus. Engine indicators with continuously-recording drums have been fairly successful when used by undergraduates for plotting pressure-waves in pipes. But electronic apparatus has not yet been tried, partly because of the difficulty of finding equipment sufficiently simple and robust ; only one firm could offer an outfit complete in every respect and ready for immediate use.

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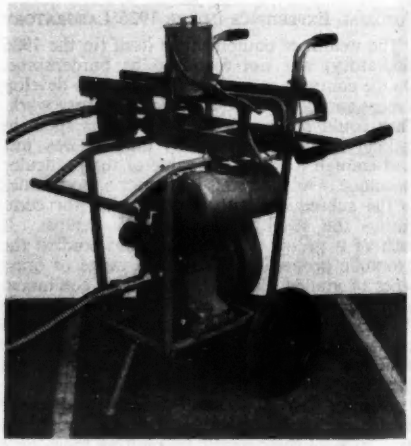
Rail Drilling Equipment

A compact portable power-operated rail drilling equipment, which is now being made by B. O. Morris, Ltd., of Briton Road, Coventry, is shown in the illustration below. The equipment has a strongly built tubular steel carriage fitted with carrying handles and wheels. Within the main frame of the carriage is mounted the power unit, a 2 h.p. petrol engine, which drives the drilling unit through a flexible shaft.

The drilling unit has a rigid plate frame, the front end of which can be fitted with suitable claws to grip the rail firmly during the drilling operation. Mounted at the rear of the frame is a small "Radicon" worm reduction unit, through which the drive is transmitted from the flexible



Portable Rail Drilling Machine

shaft to the drill head. Pressure on the drill point is applied by means of a long handle, on which the operator leans, and a conveniently placed drip can maintains a supply of coolant during the drilling operation. Means are provided to set the head along the frame to accommodate various lengths of drill.

The machine is made in two models, for drilling holes up to $\frac{15}{16}$in and 1¼in. The smaller drills are driven at 340 r.p.m. and the larger drills at 170 r.p.m. Flexible shafts, 6ft or 20ft in length, can be used with the equipment.

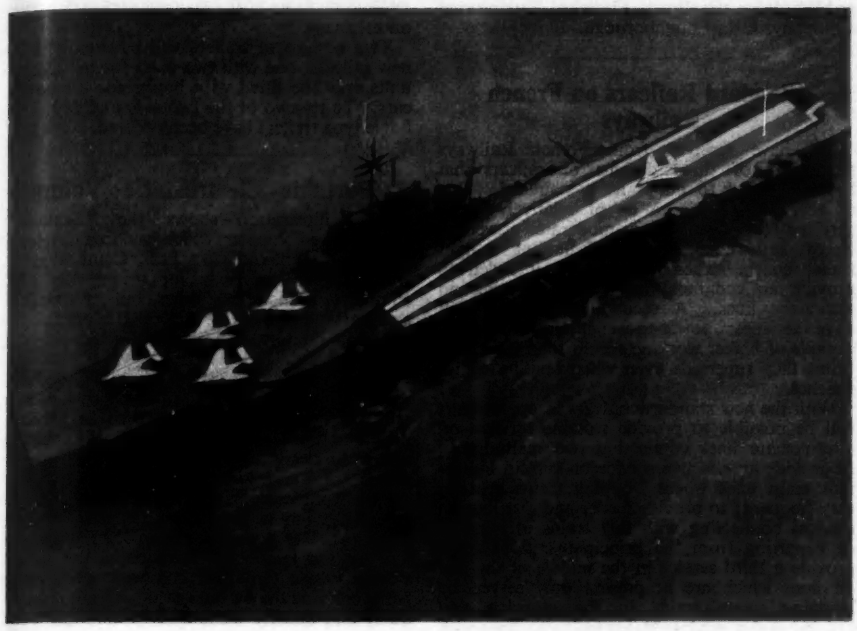
Increase in Fighting Power of Carriers

(By Our Naval Correspondent)

THE latest types of British and United States fleet aircraft carriers can accommodate over 100 aircraft and their fighting power thus largely depends on the number of aircraft which can be got into the air and landed-on in the shortest possible time. With the rapidly increasing weight and speed of modern aircraft, the catapult has been increasingly used for launching aircraft and catapulting, in lieu of flying-off, has now become the normal practice. Difficulties were, however, arising as still heavier aircraft were brought into service, for the conventional hydro-pneumatic wire purchase type of catapult had reached its practical limit of size, leaving no margin for future types of aircraft. Fortunately, the steam operated catapult—a recent British invention—has proved entirely successful under trial and is likely to meet requirements for many years ahead. Using the steam from the ship's boilers, it is quicker working and takes up less space than the conventional catapult and can operate the heaviest carrier-based aircraft. It also gives carriers the tactical advantage of being able to launch aircraft off-wind. Four of these catapults are, it is reported, to be installed in each of the large United States carriers.

The catapults are situated on the forward part of the flight deck, on which aircraft are parked, ready for launching. Abaft the deck park, barriers are erected on the deck space forward of the landing-on area, which is at the after end of the flight deck and across which are fitted arrester wires to engage the hook of the aircraft landing-on and so bring it to rest. Occasionally an aircraft will overshoot the arrester wires, in which event it is stopped by the barriers and thus prevented from crashing into the personnel and aircraft on the deck park. Barrier crashes are, however, undesirable as they usually damage the aircraft, which is not conducive to economy in carrier operations. Moreover, the increasing size and speed of aircraft tends to increase the "pull-out" of the arrester wires and the barriers, which inevitably entails enlarging the flight deck space devoted to the arrester wires and barriers at the expense of the deck park and speedy launching.

Both these disadvantages will now be overcome by the new flight deck arrangement, described in our November 21st issue, which is being developed simultaneously in the British and United States Navies, and of which a model is illustrated herewith. This arrangement, as was mentioned in that account, allows an aircraft which is not brought to a standstill by the normal method of hooking on one of a series of arrester wires, to fly off again straight over the side of the flight deck without altering course. It can then fly round again for another attempt, as is the practice at shore airfields in similar circumstances. The conventional barrier is eliminated because the way ahead is clear for the aircraft to open up to full power and take-off again if its hook has failed to engage any of the arrester wires. It may, of course, be necessary to erect a barrier in an emergency—in the rare case of a defect in the aircraft preventing it using the arrester gear, as, for example, if the arrester hook were shot away. For no useful purpose would be served by making a further attempt at landing. But in that event the emergency barrier could be erected actually in the landing area, where the arrester wires are. The angled layout once again gives aircraft the clear landing path which was available before increases in the number operated made deck parking and barriers essential. The new flight deck arrangement is, in fact, the complement of the steam catapult. While the steam catapult increases a carrier's potential in launching aircraft, the angled deck increases her potential in accepting them.



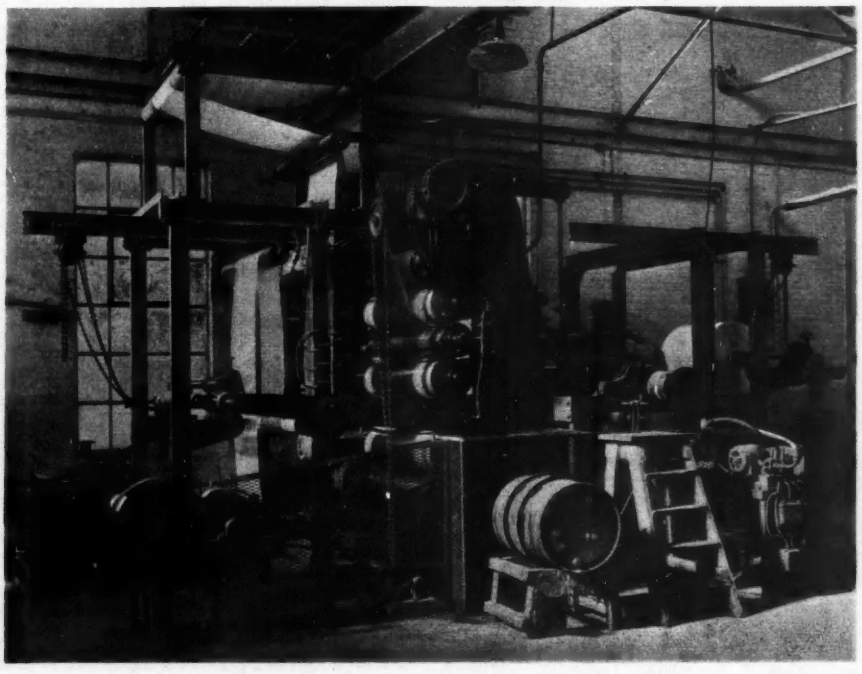
Mode of Aircraft Carrier with Angled Flight Deck

Infra-Red Drying of Paper Board

OUR illustration shows a laminating machine installed at the Treforest Mills of the British Coated Board and Paper Mills, for the manufacture of board of 3-ply paper, and other board of varying thicknesses. It has an output of 1 ton per hour.

The manufacturing process involves passing the laminations through rollers and at the same time extracting moisture from the board. The moisture extraction is effected by means of ten "Metrovick" high intensity infra-red projectors with a total loading of 66kW accurately sited in relation to the rollers; as the illustration shows, the heaters are readily incorporated in the layout of the machine. Four projectors are mounted at the top of the machine above a horizontal pass of the material and there are six projectors disposed along the subsequent vertical, downward moving, pass of the material.

These "Metrovick" electric infra-red projectors are fitted with tubular-sheathed elements, which operate at red heat and consist of a spiral of high-grade heat-resisting wire tightly embedded in a mineral insulator, enclosed solidly in an outer sheath of $\frac{1}{4}$in tube of a non-scaling, non-corrodible alloy. The process ensures not only that the spiral is held immovable in the centre of the bore but also that an even thickness of insulation separates it from the sheath. The projectors themselves consist of trough reflectors in a robust frame designed for maximum strength consistent with light weight. The reflectors are constructed from high-grade aluminium sheet, which has been subjected to a special anodising process to give maximum heat reflection and to protect it from atmospheric corrosion.



Infra-Red Drying of 3-Ply Coated Board

High-Performance 150V Stabiliser for Electronic Equipment

A HIGH-PERFORMANCE stabiliser working at 150V and designed for communications and industrial electronics equipment, has been introduced by Mullard, Ltd., Century House, Shaftesbury Avenue, London, W.C.2. It is known by the designation "150B2" and is of the same basic construction as the miniature "B7G" valve. Under conditions where a comparatively constant load current is taken, the "150B2" valve should provide the stability and freedom from sudden large jumps in output voltage, which are important considerations in all measuring equipments.

The principal characteristics of the "150B2" valve are as follows :—

Minimum voltage necessary for ignition ...	180V
Burning voltage (variation from tube to tube)	143–147V
Current range	5–15mA
Incremental resistance (max.)	500 ohms
Temperature coefficient of burning voltage	10mV per deg. Cent.
Ambient temperature limits	−55 to +90 deg. Cent.

The "150B2" valve is intended to be used as a simple stabiliser over the current range of 5mA to 15mA where the stability with time is the most important factor. In the design of the tube the Mullard sputtered-metal technique (as used in the manufacture of the voltage reference level tubes "85A1" and "85A2") has been applied to ensure freedom from trouble caused by the liberation of contaminating gases from the walls of the tube.

As regards burning voltage, the temperature coefficient is low and the stability at any one current is better than the figure of ±1 per cent over the life of the tube.

High-Rupturing Capacity Fuses

A RANGE of high-rupturing capacity fuses has been developed at the Cardiff works of the Brush Electrical Engineering Company, Ltd. This range of H.R.C. fuses covers current ratings from 2A to 300A and is fully tested for performance in accordance with B.S. 88/1947.

The Brush H.R.C. cartridge fuse links employ fusible elements of pure silver embedded in an inert granular material of controlled size, enclosed in a cylindrical ceramic body. The fusible elements have one or more calibration sections which volatilise under fault conditions, whereupon the resulting arc is absorbed by the surrounding filling, with the formation of a non-conducting section of high breakdown value. Harmful voltage rises caused by operation of the fuse are eliminated by the presence of high-resistance, small-diameter shunt wires. One of these wires is arranged to give a visual indication of the healthy or "blown" condition of the fuse. Each end of the ceramic cartridge is covered by a cap fitted with a connector of high-conductivity copper, all external current-carrying parts being electro-tinned.

Details of the fuses, including their short-circuit performance, time-current characteristics, and application to the protection of motor circuits, are given in a leaflet, No. 81001, published by the Brush Electrical Engineering Company, Ltd., Loughborough.

Standard Railcars on French Railways

WE have received from French Railways particulars of three designs of railcars that it has decided to adopt as a standard. One of these railcars is to be of relatively small carrying capacity with a moderate power-to-weight ratio and capable of hauling a light trailer coach. These railcars are intended to provide an economic means of operating on secondary lines. A second new design will have a larger power-to-weight ratio and be capable of higher working speeds than the steam trains they supersede even when hauling trailer coaches.

With the new standard railcars in operation it will be possible to provide suitable services on intermediate lines connecting two main lines; to provide an effective service on certain important main lines where stopping trains are not very frequent; to provide feeder and distribution services connecting with fast trains arriving at or departing from the principal stations; to provide a third service in the middle of the day on lines which are at present only served by stopping steam trains in the morning and evening and to replace steam trains on lines with only light or medium traffic.

The smaller railcar will be fitted with a road-vehicle-type engine of 150 h.p. or 160 h.p., and its weight will be limited to about 30 tonnes. It will carry sixty-six seated and fourteen standing passengers and will haul a two-axled trailer coach seating sixty passengers. The maximum speed of 62 m.p.h. will be reduced to 50 m.p.h. when hauling a light trailer coach. We are informed that twenty railcoaches of this design have been ordered.

In the second category of standard railcars the French Railways is using units with two 300 h.p. engines and the design of nineteen now on order has been developed from similar vehicles at present giving satisfactory service. As, however, it would not be economic to use the 600 h.p. cars for all the services for which the 150 h.p. cars are not suited, a third design of standard railcar of 300 h.p. was decided upon for intermediate duties.

This third design of railcar can be coupled to a similar unit when required and, where track conditions permit, a trailer coach can be added. Seventy-six of the new 300 h.p. cars have been ordered and one of the new vehicles is illustrated on this page.

Two designs of trailers will be used with the new railcars, one with two axles for the 150 h.p. units and one fitted with bogies for the heavier cars. Thirty-two of the two-axle and 110 of the bogie type trailers have been ordered.

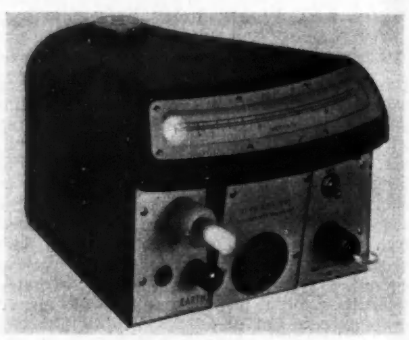
300 H.P. Railcar for French Railways

A Portable Electrostatic Voltmeter

OUR illustration shows the "Scalamp" electrostatic voltmeter, which has been developed by W. G. Pye and Co., Ltd., Cambridge. It was designed primarily for testing the e.h.t. circuits of cathode ray tubes, but its simplicity and portability make it generally applicable for precision e.h.t. measurements in research and industry.

The movement consists of a specially designed vane held close to a well-insulated electrode by a taut suspension of the kind used in galvanometers. This movement is critically damped under all circumstances by a magnet damping device.

The voltmeter uses an optical indicating system having a lamphouse integral with the front panel of the instrument. On the inside face of the lamphouse is mounted the optical system. The external face comprises a removable panel carrying the 4V bulb, which can be changed easily and quickly without disturbing any other components of the instrument. Morever, when the bulb is changed the "Scalamp" interior remains sealed off from the outside by the lamphouse.



"Scalamp" Electrostatic Voltmeter

In its standard form the "Scalamp" electrostatic voltmeter is fitted with a transformer for use on 200V–250V a.c. mains. Connection is made via a two-pin safety plug recessed into the front panel. For portable use, or where no mains supply is available, removal of a shorting bar allows the instrument to be operated from a 4V battery. A switch, which is operative on both the mains and battery connection, allows the lamp to be switched on and off as required.

A moulded plastic case encloses the whole assembly, all the joints in the case being sealed with rubber strip against the ingress of dust. The only orifice in the case is that embracing the "set zero" knob, and it is sealed by a thick "Sorbo" rubber ring. As can be seen from the illustration, the instrument scale is set at a convenient reading angle.

There are three "Scalamp" electrostatic voltmeters, to cover the following voltage ranges: 1kV to 5kV on a.c. or d.c.; 3kV to 10kV on a.c. or d.c.; and 5kV to 18kV on d.c. and 5kV to 12kV (r.m.s.) on a.c. On all d.c. and a.c. ranges, up to 12kV (r.m.s.) and 100 Mc/s the instrument error is stated to be within 1 per cent, and the period is given as three seconds.

American Toll Roads

(By Our American Correspondent)

In the United States, as in Britain, motorists to-day argue that they are contributing enough in taxation, both on their vehicles and on their fuel, to provide sufficient funds for any scheme, however ambitious, of new and improved roads. Yet there is a still growing tendency in America to extend the financing of major new road works construction on the toll principle, in an effort to supplement the largely inadequate general road building programmes undertaken by the federal and state governments. To-day the American road user pays tolls of up to 4 cents per mile to drive over "super-highways" in eight states, and toll roads are now under construction in these and three other states. In the early days of the motor-car the aim was to keep all highways free of toll gates, and the U.S. Bureau of Public Roads as well as most state highway departments, still cling to that policy. It is generally believed that the present tendency towards the building of toll roads can be traced to two developments, the inability of federal and state highway construction programmes to keep up with traffic demands with the funds available and the precedent of the Pennsylvania Turnpike scheme, which has proved such an outstanding success—from the point of view of the financier as well as the motorist! Ironically, in view of the Washington authorities' distaste for toll roads, it was the federal government which made the Pennsylvania Turnpike possible. That highway was built when construction costs were low in relation to present costs and its financing, involving 70,000,000 dollars, was aided by a grant of 29,250,000 dollars from the Public Works Administration. Providing an easy-grade route through the mountainous parts of Pennsylvania, there can be no doubt that this highway met a long-felt need. Nevertheless, owing to petrol rationing during the last war, its income was mostly below the official estimates until 1946. Since the end of rationing, however, the turnpike income has risen steadily until last year the gross income was almost 14,000,000 dollars against operating costs of 2,675,000 dollars and interest requirements of 1,058,000 dollars on bonds issued to cover the original construction costs, which were refunded in 1948.

To-day, tolls are collected on 750 miles of highway in the United States and, within three years' time, there will be a continuous toll highway system from New York City across New Jersey, Pennsylvania and Ohio to the Indiana state line, and probably another one extending from Boston across Massachusetts and northern New York to the Ohio state line. Furthermore, there is in the making a north-south system, for which the West Virginia Turnpike forms the nucleus. Even the most ardent advocate of toll road construction must realise that this development in America involves two serious dangers. One is the fact that these various highway systems have taken form without any overall planning. The second is their high cost, in terms of construction costs, operating charges and, particularly, interest on investment capital. The lack of planning is probably the consequence of the adamant refusal by the U.S. Bureau of Public Roads and most state highway departments to have anything to do with toll highway systems and to the uncontrolled urge of the individual authorities promoting toll turnpikes to "get on with the job" in a manner best suited to their own ideas. The relatively high cost of the money borrowed on revenue bonds to finance toll highways was of little national importance ten years ago. But now that the investment in toll roads built or authorised is in excess of 2,000,000,000 dollars, the high cost of not having put the "faith and credit" of a state behind most of the bonds issued to build those roads is becoming serious. For lack of such state support, most of the turnpike authorities are paying interest rates about 1 per cent higher than would be paid if state credit had been placed behind them. The revenue bonds issued to build the Maine Turnpike were sold with interest rates of 2·50 and 2·75 per cent. On the other hand, the bonds issued by New Hampshire, with full state credit behind them, to provide a continuation of the Maine Turnpike to the Massachusetts state line, were sold with an interest rate of only 1·6 per cent. The revenue bonds sold recently by the Ohio Turnpike Commission carry a rate of 3·25 per cent, while the state of New York, with full state credit backing of the "Thruway" Authority bonds, expects to finance its "Thruway" at an interest cost of about 2 per cent.

While in the early days of the toll roads movement the private financing of highway schemes through Wall Street financial houses may have been deemed to serve as a welcome check on economically unsound projects, to-day's costs of the major road works, which are so urgently required by many states, would seem to call for the adoption of a system of official bond financing, backed by state credit every time. It is probably too late to avoid payment of high interest rates on most of the bonds already issued, but there are ways in which the total amount of the payments could be reduced, and there are ways, so far largely unexplored, of cutting the total cost of toll highways. It is also probably too late to correct all the errors that have been made in laying out toll roads without due regard to regional highway needs. Some existing errors, however, can be corrected and future ones can be avoided if integrated planning of toll roads throughout the country is started soon. It has been suggested that certain federal highway construction funds should be used to pay part of the cost of future toll roads. The new Republican administration is likely to liberalise federal aid to highway works, and such aid has already been approved for the next two fiscal years at the rate of 575,000,000 dollars a year. Whatever the method finally adopted, it is to be hoped that it will prove possible to put American toll road systems on a more economical and co-ordinated basis so that the motorist may reap the fullest benefit of the efforts being made on his behalf.

American Engineering News

(By Our American Correspondent)

Wireless Wave Propagation at Very High Frequencies

A recent joint investigation by the National Bureau of Standards, of Washington, D.C., the Massachusetts Institute of Technology, of Cambridge, Massachusetts, and the Collins Radio Company, of Cedar Rapids, Iowa, has led to the discovery of a new kind of wireless wave propagation at very high frequencies due to ionospheric reflections. The results obtained to date indicate the uninterrupted presence of weak but observable signals over a 774-mile test path, and suggests that the signals are returned from a part of the *E*-layer of the ionosphere (between 50 and 70 miles above the surface of the earth) near or just below the absorption region for high frequency wireless waves. By definition, v.h.f. wireless waves cover a 30 M/c to 300 M/c frequency range, and their propagation to distances substantially beyond the horizon has been observed for many years. The propagation can nearly always be attributed to one of two causes. At short and intermediate ranges, special conditions prevailing at times in the troposphere usually provide an explanation. At greater distances, propagation is usually attributable to ionospheric reflections. Very high values of the *F*2-layer critical frequency, above which frequency the waves are not propagated, account satisfactorily for occasional cases of fairly strong fields at distances of several thousand miles, while sporadic *E*-layer ionisation often accounts for erratic but strong fields out to distances of about 1200 miles. It is known that the distribution of ionisation in the ionosphere has a fine structure capable of producing incoherent scattering of wireless waves. Even under quiet ionospheric conditions, there are turbulent motions in the ionosphere which lead to the fading of single "rays," quite apart from fading due to interference between two or more rays. The question arose as to the possibility of detecting scattering caused by irregularities in the ionosphere when other forms of ionospheric transmission were absent. A theory on tropospheric scattering had been presented earlier by Booker and Gordon. The need for experimental work was evident; and early in 1951, suitable transmissions were initiated.

The transmitter, operated by the Collins Radio Company at Cedar Rapids, Iowa, radiated continuous-wave signals at a frequency of 49·8 M/c, which were directed toward the receivers of the National Bureau of Standards at Sterling, Virginia, at a distance of 774 miles. The r.f. power to a horizontal rhombic antenna was an estimated 23kW. Similar antennas were used at both the receiving and transmitting sites, each 41·2ft high, having 500ft legs and a tilt angle of 83 deg. Signals were received continuously from the outset, and the tests were continued to establish the diurnal and seasonal characteristics of received signals and the behaviour of the signals during ionospheric disturbances. A striking characteristic of the received signal, which exhibits fading characteristics that seem to follow a Rayleigh distribution, is the presence at all times of day of random heterodyne whistles, mostly descending in pitch. They are believed to be caused by reflections from the moving head of ionisation accompanying meteors in their passage through the *E*-layer and the lower parts of the atmosphere. The whistles, which vary enormously in intensity, according to the geometry of the situation and the size and velocity of the meteor, are relatively infrequent and of long duration in the evening and frequent and of short duration in the dawn hours. Furthermore, a meteor giving a strong whistle sometimes causes the signal level to rise abruptly and to remain high for periods ranging from several seconds to as much as a minute or more. It seems likely that this meteoric residue makes an important contribution to the mean signal level.

A pronounced evening minimum of signal intensity has always been observed. It is followed by a fairly steady rise during the night, a secondary maximum in the forenoon, and a midday maximum. Such diurnal behaviour suggests that the received signal can be thought of as resulting from at least two distinct causes. One is the ionisation produced by meteors, which make a maximum contribution at dawn and a minimum contribution at sunset. The other is the solar ultra-violet radiation, which has a peak at midday and is absent at night. A superposition of the diurnal variations associated with these two causes, with relative importance varying according to season, would account reasonably for several aspects of the observed monthly diurnal characteristics. The records of the received signals were carefully examined during times of magnetic disturbances and h.f. radio fading. During the most severe magnetic disturbance for which observations were available, the signal showed pronounced intensification. During more moderate disturbances, the signal occasionally showed some enhancement or appeared normal. Analyses of h.f. records during April and May, 1951, showed twenty-four "sudden ionosphere disturbances" between

1½ hours after sunrise and 1½ hours before sunset, for which simultaneous data are available on the experimental path of v.h.f. wave propagation. In seventeen of these events, the received signal showed an increase ranging from 3 db to 9 db during the period of sudden ionosphere disturbance. This amplification became noticeable within a few minutes of the onset of the sudden ionosphere disturbance, and the received signal returned to normal at the end of the fade-out. In the remaining seven cases of h.f. fading the records of received v.h.f. signal did not show any strengthening but appeared to be normal; an important point is that there was no evidence of any weakening of the signal. These results indicate strongly that the received signal is returned from a part of the *E*-layer below the level of maximum ionisation, and perhaps from below the absorbing region which is sometimes referred to as the *D*-layer. This theory is supported by earlier and independent observations of cosmic noise, which suffers a small but noticeable attenuation at the same frequency during sudden ionosphere disturbance.

Other observations of the experimental transmissions have been made, notably by the Bell Telephone Laboratories, by Cornell University, and by radio amateurs. It is evident from these observations that the signal can be received over a considerable area. During a short period, receiving tests were also made in Bermuda, a distance of 1600 miles from Cedar Rapids. Signals were received sporadically and only at times associated with intense sporadic *E*-layer ionisation at some point along the path. In the pre-experimental calculations, it was estimated that the received signal power corresponding to a critical frequency of 1·55 Mc/s and coming from a height of about 100 km would be $2{\cdot}0\times10^{-15}$W. An inspection of records revealed that the maximum median values of received signal varied in the middle of the day from power levels of about $4{\cdot}2\times10^{-15}$ to $1{\cdot}7\times10^{-13}$W. These values, which represent very weak signals, occurred at times when the highest usable frequency for the usual kind of *E*-layer reflection for this path varied from 13·8 Mc/s to 14·4 Mc/s—well below the operating frequency of 49·8 Mc/s. It is thus apparent that the pre-experimental speculations were too optimistic. The behaviour of the signal during sudden ionosphere disturbances suggests that the ionospheric region responsible for the transmission may be lower than 100 km. At such lower heights the values of the critical frequencies corresponding to the electron densities normally present are substantially lower, although they probably exhibit similar diurnal and seasonal variations. It would appear that the adaptation of the Booker-Gordon theory to the ionosphere could account more readily for the experimental results if use were made of values of critical frequency which are appropriate to the lower heights from which the signals seem to come. Experimental results, to date, while of considerable interest, leave many questions unanswered. For future experiment, tests of frequency and distance dependence are contemplated, as well as more detailed study of the nature of the received signal, with the object of improving understanding of the transmission mechanism and the parameters of the medium.

Electric Power for Uranium Production Plant

The U.S. Atomic Energy Commission has announced the approval of an agreement with Electric Energy, Incorporated, a group of five private power companies, to supply an additional 235MW of power for the operation of the Commission's uranium-235 production plant which is now under construction near Paducah, Kentucky. The total power requirement of the plant is 1940MW. The new agreement increases the total power to be supplied by Electric Energy, Incorporated, from 500MW to 735MW. The 235MW represents 25 per cent of the additional power required due to the expansion programme in effect at the gaseous diffusion plant in Kentucky. The Tennessee Valley Authority will provide the remaining 75 per cent of the new requirement, 705MW, and thus will eventually supply a total of 1205MW.

The annual costs of power when the Kentucky plant is in full operation are estimated at about 23,100,000 dollars to be paid to Electric Energy, Incorporated, and about 37,000,000 dollars to be paid to the T.V.A. The power costs charged to the A.E.C. by Electric Energy, Incorporated, will be based on fixed charges and costs of the power generating facilities at Joppa, Illinois, operating expenses and fuel. It is estimated that approximately 3,000,000 tons of coal will be burned each year in the generating plant. The power station will be expanded from a four-unit steam generating plant to a six-unit plant to meet these new power requirements.

The A.E.C. has also approved a similar agreement with a group of fifteen private power companies, known as the Ohio Valley Electric Corporation, to supply 1800MW of electric power which is required to operate the uranium-235 production plant being constructed in Pike County, Ohio. This agreement also provides that the corporation will design and construct the necessary generating capacity, provide reserve capacity from its systems and make available up to 465MW of power from its existing systems, for construction and early operation of the new gaseous diffusion plant, prior to completion of the new generating facilities. The annual costs of power when the plant is in full operation are estimated to be about 60,000,000 dollars. The power costs to the Commission will be based on fixed charges and costs of the power generating facilities, operating expenses and fuel.

A Wide Aluminium Tapered Sheet Rolling Mill

A large rolling mill suitable for the production of wide aluminium alloy tapered sheet and plate for the aircraft industry will be installed at the Davenport, Iowa, works of the Aluminum Company of America and is expected to start operation by the end of 1953. The mill will be designed, installed and operated by the Aluminum Company of America under the terms of a lease arrangement with the Air Material Command of the United States Air Force. The mill, capable of rolling widths up to 10ft through four-high stands of rolls, will be able to handle hot or cold ingots, and it will be reversible. Davenport, Iowa, was selected as the mill site because of the other modern facilities already existing there, including large heat-treatment furnaces and wide continuous rolling equipment. Supplementary facilities, including an intermediate leveller and pre-heating and aging ovens, are being provided to complement the rolling mill.

Tapered sheet and plate are already being used in the fabrication of aircraft wings. The thicker end of the sheet is placed near the fuselage of the aircraft; thus, the sheet tapers toward the wing tips, where not as much strength is required. The principal design advantage of tapered sheet and plate over that of uniform thickness sheet or plate is a weight saving up to 35 per cent without loss of strength. Tapered sheet will be produced on the new mill in lengths exceeding 33ft. Present equipment limits the production of rolled tapered sheets to widths slightly over 5ft 6in and to lengths of 25ft. The extra wide and long sheet which will become available can replace two or three narrower sheets and thus eliminate many costly joining operations during construction of both civilian and military aircraft. The success of the rolled tapered sheet and plate process and the acceptance of both products by aircraft manufacturers are indicated by substantial recent increases in the use of rolled tapered sheet and plate by the American aircraft industry.

CODE OF PRACTICE FOR METAL FIXING.—The Metal Fixing Association, 32, Queen Anne Street, Cavendish Square, London, W.1, has published its first code of practice covering lightweight metal fixing systems for building linings and ceilings. The Association states that the code has been produced to meet the demand for higher standards and improved design in the use of metal fixing systems. The code lays down minimum standards for metal components, insulating fibre boards, and anti-corrosion protection and describes in detail the requirements for methods of fixing linings and ceilings. In addition, it sets out the data suggested for specifications and enquiries for quotations. Copies of the code are freely available from the secretary of the Association at the above address.

Torsional Vibration in Diesel Engines

ON Thursday, November 20th, C. H. Bradbury read a paper, before the Diesel Engine Users' Association, entitled "Torsional Vibration in Diesel Engines—Some Observations and Practical Aspects," which we summarise below.

It is stated in the paper that in 1900 Bauer first showed that dangerous torsional vibration could exist in the crankshafts of steamships, and this is followed by some historical notes on the subject. A survey of torsional vibration in diesel engine crankshafts says that the prime cause is periodically varying cylinder torque acting on an elastic shaft system which has inherent frequencies governed by the proportions of the shaft and attached masses. The harmonics making up the varying cylinder torque can be evaluated by Fourier's theorem and a diagram illustrates an example of a harmonic analysis of turning effort, while others show the harmonic components for a four-cycle engine for orders up to twelve.

The two-mass, one-shaft system is illustrated and a simple equation is given for obtaining the natural frequency and then the resonance set up in the system by adding a pulsating torque is discussed. Multi-mass systems, which are those where torsional vibration problems are mainly encountered, are reviewed and the normal elastic curve for a six-cylinder diesel engine, together with phase diagrams, are shown, while another drawing represents the critical speed spectrum of the engine. A modified firing order is used to demonstrate that although the firing order does not affect the major criticals it has a limited effect upon the relationship between the minor criticals. Before an engine system can be set down the crankshaft must be reduced to an equivalent uniform shaft of known stiffness and the moment of inertia per cylinder line calculated. In the paper it is stated that the most accurate formula for the crankshaft is that published by the British Internal Combustion Engine Research Association.

In calculating the natural frequency it is recalled that certain equations, if of power higher than third, can only be solved by the Remainder Theorem. An alternative tabular method is mentioned and the method devised by Gorfinkel is described and demonstrated by tables in which Gorfinkel calculation constants for frequency and normal elastic curve for engines, having five to eight cylinders, are recorded.

The amplitude in a critical speed cannot be calculated accurately, mainly due to lack of knowledge of the controlling factors, but formulæ based on test results are in use. A graph shows a plot of some test results of the dynamic magnifier for engines having various numbers of cylinders and the scatter is bounded by two lines, the dynamic magnifier represented by the upper line being recommended to be used. The relationship between the dynamic magnifier and the number of cylinders established by the line is stated and a formula deduced to give the maximum value of the amplitude in a critical speed.

A general review of the stress calculations is given and attention is drawn to the main points of stress concentration in the crankshaft. This is followed by some notes upon limiting stresses as revealed by endurance tests. The subject of damping is examined further and some of the work done in this field is described and commented upon. Turning to the control of critical speeds, the paper recalls that natural frequency control is governed solely by shaft stiffness and the magnitude of the associated masses and where it is not practicable to change the natural frequency a torsional vibration damper is generally fitted. The introduction of high viscosity silicones has facilitated the construction of a damper of high promise. This damper, of which illustrations are given, consists of a ring of rectangular section, forming the inertia member, hermetically sealed in a housing in which the side clearances are filled with high viscosity silicone. A graph shows the effect of the damper on an engine having a pronounced sixth order critical.

Appendices to the paper give calculations of harmonic components without reference to an engine indicator diagram; equivalent lengths of crankshafts; Gorfinkel tables and the approximate calculation method for a viscous torsional vibration damper.

Industrial and Labour Notes

Western Europe's Economic Situation

The United Nations' Economic Commission for Europe has published this week its *Economic Bulletin for Europe*, which reviews the second quarter of this year. During that period, it is stated, economic activity continued to decline in most of Western Europe and industrial production was generally lower than in the corresponding period of 1951. In the United Kingdom, according to the *Bulletin*, industrial production was about 5 per cent lower in the second quarter of this year than in the corresponding quarter of 1951, and was even somewhat below the level reached in 1950. Western Germany and France were exceptions, although, it is commented, "even those countries were affected by the recession." In smaller industrial countries the pattern was similar and production either failed to rise or actually fell.

The *Bulletin* goes on to say that, while the general pressure on resources was thus diminishing, most governments, nevertheless, found it necessary to reduce their rearmament programmes because of balance-of-payments troubles and also because of budgetary difficulties or bottlenecks in the engineering industries. But it is suggested that the resulting reduction of pressure on specific raw materials and engineering capacity should make it easier in the future for European countries to supply metal goods to foreign markets. At the same time, it is remarked, the demand for exports other than metals has been contracting, and such improvement as there has been in the balance of payments situation in particular countries has been brought about mainly by import cuts. "One of the unfortunate effects of these cuts," the *Bulletin* adds, "has been renewed protection for certain industries, including those which have failed to increase exports."

Dealing with the trading activities of particular industries in the second quarter of this year, the *Bulletin* says that, in contrast with other branches, the engineering industries continued to prosper, owing to rearmament, the continued big demand from overseas countries, and increased sales of motor vehicles. It is stated that the progress of the engineering industry was especially marked in France, Western Germany and Austria, the United Kingdom making only "slight progress," owing to the shortage of steel. In the Scandinavian countries, the *Bulletin* comments, the stagnation in the engineering industry is mainly due to inadequate export demand.

Index of Industrial Production

The index number of industrial production in the United Kingdom (1948=100), which is prepared by the Treasury, has been provisionally estimated as 115 for all industries in September, compared with 99 in August. The numbers for the corresponding months last year were 121 in September and 104 in August. Taking various industry groups, the September index for "mining and quarrying" is given as 113, compared with 112 a year earlier, and that for "manufacturing" is estimated as 115, compared with 124 in September, 1951. For "building and contracting," the September index number is given as 109, against 111 for September last year, and for "gas, electricity and water" the September figure is 120, compared with 113 last year. It is stated that, on the basis of information so far received, the index number for all industries in October this year is expected to be 121 or 122.

Changes in Wage Rates

Changes in weekly and hourly rates of wages which were reported to the Ministry of Labour as coming into operation in the United Kingdom during October resulted in an aggregate increase of approximately £159,000 in the weekly full-time wages of 615,000 workpeople and in a decrease aggregating about £17,000 in the wages of 246,000 workpeople. Those receiving increases during October included people employed in industrial canteens, and bus and trolleybus drivers and conductors in London. The decreases in wage rates occurred as a result of sliding-scale arrangements based on the index of retail prices. They affected workers in the iron and steel industry and in iron ore mining and quarrying.

The Ministry of Labour states that in the first ten months of this year changes in wage rates resulted in an aggregate increase of £3,290,330 a week for 8,493,000 workpeople. In the corresponding months of last year there was a net increase of £4,536,000 in the weekly full-time wages of 9,765,000 workpeople. At the end of October the index of rates of wages (June, 1947=100) was 131 for all workers, compared with 126 at the end of last year.

Copper Allocations

At the beginning of this week the Ministry of Materials announced the withdrawal of the restriction imposed last month on the forward purchasing of copper. This means that consumers may now buy, until further notice, copper for delivery in the current and immediately succeeding months up to the full limit of their existing allocations.

At the same time, the Ministry stated that its buying price for rough copper had been reduced from £235 to £230 a ton.

Engineering Wages

Last week it was stated that an increase of 6s. 5d. a week in the pay of women workers, of eighteen and over, in the engineering industry had been agreed between the Engineering and Allied Employers National Federation and the trade unions concerned. Proportionate increases in the wages of girls under eighteen were also agreed upon. The increases apply from November 10th, on which date the 7s. 4d. a week increase for adult male workers became effective.

A claim for an increase in the pay of draughtsmen and clerical workers in the engineering industries was submitted last week to the Engineering and Allied Employers National Federation by the appropriate unions.

Iron and Steel Scrap

The Minister of Supply was asked in the House of Commons last Monday how long it was intended to continue the subsidy in respect of iron and steel scrap recovery; and how far the estimated increase, from £370,000 in 1951–52 to £490,000 in 1952–53 in respect of administration and transport of iron and steel scrap was now likely to be realised.

In a written reply, the Minister has pointed out that the Government has not for a long time paid any subsidy for scrap. It collects and sells, however, to the British steel industry, Government-owned ships for scrapping and scrap lying overseas. Owing to an increase in the amount of such scrap which has become available, it is estimated that the costs of recovery will rise to about £600,000 in 1952–53. The reply adds that the amount to be paid by the steel industry for that scrap will, of course, greatly exceed that figure.

Membership of Trade Unions

In the November issue of the *Ministry of Labour Gazette*, an analysis is given of the returns made by the Chief Registrar of Friendly Societies in respect of trade unions registered under the Trade Union Acts, and of returns supplied direct to the Ministry by unregistered organisations. It states that, at the end of last year, the aggregate membership of trade unions in the United Kingdom was about 9,480,000. It was the highest figure ever recorded, being about 238,000 more than the total at the end of 1950 and about 207,000 more than the total at the end of 1949. The number of trade unions at the end of 1951 was stated to be 704, of which total 138 unions each had a membership of less than 100; 184 each had a membership of between 100 and 500; fifteen had a membership numbering between 50,000 and 100,000, and seventeen had a membership of over 100,000. The growing tendency towards amalgamation of trade unions is shown by the fact that at the end of 1937 there were 1032 separate unions.

The Ministry of Labour says that in 1892—the earliest year for which statistics are available—the total membership of trade unions was a little over 1,500,000, and by 1910 it had reached a total of only 2,500,000. The total then increased year by year, with a few exceptions, until 1920, by when it had reached nearly 8,350,000. Subsequently the total membership declined almost continuously until 1933, when it was just under 4,400,000. In the following year it began to rise again, a trend which has continued in most years since then. At the end of last year the number of federations of trade unions in the United Kingdom was forty-nine, or three less than at the end of 1950. Although a large proportion of the unions are affiliated to federations, some, of course, are not affiliated and others are affiliated in respect of only a part of their total membership. On the other hand, many trade unions, or branches of them, are affiliated to more than one federation.

The Ministry's analysis includes some details of trade union membership in the various industries of the country. In the group classified as "metal manufacture, engineering, shipbuilding, electrical goods, vehicles and other metal trades," trade union membership at the end of last year totalled 1,703,490 (1,632,130 men and 71,360 women). At the end of 1950 the total was 1,648,410 (1,591,500 men and 56,910 women).

Trade Disputes

During the month of October, there were 163 stoppages of work through industrial disputes in the United Kingdom which were reported to the Ministry of Labour. They included seventeen stoppages which had begun earlier but were still in progress in the early part of October. The stoppages involved 25,000 workpeople, directly and indirectly, and resulted in an aggregate loss during the month of 91,000 working days. Of the total number, 113 stoppages occurred in the coal-mining industry, resulting in the loss of 43,000 working days by 16,100 people. In the first ten completed months of this year the number of work stoppages through industrial disputes was 1472, involving 314,900 workers and causing an aggregate loss of 1,530,000 working days. Last year, in the corresponding period, there were 1516 stoppages, involving 336,500 people and resulting in an aggregate loss of 1,561,000 working days.

Industrial Disputes in Canada

Some information has been published in the *Ministry of Labour Gazette* about stoppages of work through industrial disputes which occurred in Canada during 1951. It is stated that the stoppages which actually began in 1951 numbered 257, the total number in progress during the year being 259, an increase of more than 60 per cent compared with the preceding year. But there were fewer workers involved in the stoppages last year and a reduction in the number of working days lost. In all the stoppages in 1951 there were 102,870 workers involved and 901,739 working days lost. The statistics show, however, that in the manufacturing industries of Canada last year the loss of working time owing to stoppages through disputes was greater than in all other industries combined and, in fact, amounted to 74 per cent of the total time lost throughout the year. The mining industry last year accounted for 16 per cent of the total time loss in all industries through stoppages arising from disputes.

Notes and Memoranda

Rail and Road

LOCOMOTIVE CABS.—A hundred "YP" class locomotives which are at present under construction by the North British Locomotive Company, Ltd., for the Indian railways are being fitted with aluminium alloy cabs and platforms. The material has been supplied by James Booth and Co., Ltd., and the primary joints between the aluminium alloy and steel structures are riveted, while the secondary joints are welded. One of the engines will be shown at a railway equipment exhibition, to be held in Delhi next year.

RHODESIA RAILWAYS APPOINTMENT.—It is announced that with the approval of the British Transport Commission, the Railway Executive has agreed to release Lt.-Col. H. B. Everard, chief officer engineering (maintenance), Railway Executive, to take up the appointment of general manager, Rhodesia Railways, with effect from January 16, 1953. Lt.-Col. Everard will succeed as general manager Sir Arthur Griffin, who is to become chairman of the Rhodesia Railways Board. Lt.-Col. Everard joined the old Midland Railway in 1922 after service in the Army during the first world war. He served in various capacities until 1934, when he was appointed district engineer, Derby (South). He rejoined the Forces in 1939 and was later taken prisoner of war. In 1945 he resumed duties with the former L.M.S. Railway and in 1949 was promoted to the position he now relinquishes with the Railway Executive. For his war services Lt.-Col. Everard was awarded the D.S.O. and he is an associate member of the Institution of Civil Engineers.

Air and Water

JET DELIVERIES TO DENMARK.—The first four jet night fighters of an order from the Danish Government have recently been delivered. The aircraft are Armstrong, Whitworth "N.F11" machines.

INSHORE MINESWEEPER.—Her Majesty's inshore minesweeper "Altham" was launched from the yard of Camper and Nicholsons, Ltd., on December 2nd. The vessel has a length of 106ft 5in and a beam of 20ft 6in and is powered by engines built by Davey, Paxman and Co., Ltd.

FIRST OIL SHIPMENT.—Following the official inauguration of the Mediterranean terminal of the pipeline which has been constructed for the Iraq Petroleum Company, Ltd., and links Kirkuk with Banias on the Mediterranean coast, the first oil was pumped on board the 28,000-ton deadweight oil tanker "British Talent." The ship, which is owned by the British Tanker Company, Ltd., will deliver the crude oil at Loch Finnart early in December.

AIRWAYS OPERATING AND TRAFFIC STATISTICS, MAY, 1952.—In the five weeks ended May 31st this year B.O.A.C. flew more than 70,000,000 passenger miles and carried more than 22,000 passengers. The total revenue load flown was almost 11,000,000 short ton-miles, while the overall revenue load factor improved to approximately 67 per cent. Revenue traffic on B.E.A. services in May rose to almost 3,500,000 short ton-miles, an increase of 9 per cent over last year, while the overall revenue load factor achieved was 63 per cent. The Corporation carried 107,000 passengers, 1400 tons of freight and 540 tons of mail, representing increases of 11 per cent, 21 per cent and 6 per cent respectively. Passenger miles flown by independent airlines in association with the Corporations were more than double last year's figures, reaching over 900,000. The passenger load factor improved to 58 per cent, compared with 53 per cent last year.

Miscellanea

INSTITUTION OF MINING AND METALLURGY.—The council of the Institution of Mining and Metallurgy announces that H.R.H. The Duke of Edinburgh has graciously accepted election to honorary membership of the Institution.

"BOMBAY WATER SUPPLY."—Our issue of October 31st last contained an article under this title. In Table III, on page 571, an error occurred. Under "Name of Contractor" a firm was entitled "Hindustan Construction, Ltd." This should have read "Hind Construction, Ltd."

OIL ENGINE BROCHURE.—We recently received from Rolls-Royce, Ltd., a brochure setting forth the principal particulars of the four, six and eight-cylinder oil engines which form the range of engines designed to basic specification. A description of a six-cylinder, four-stroke, supercharged engine, model C6.8FL, which is generally applicable to the other models.

A LARGE DYNAMOMETER FOR DENMARK.—We are informed by Heenan and Froude, Ltd., that it has just dispatched from its Worcester works what will be the largest dynamometer in use in Scandinavia. This dynamometer has a capacity of 15,000 b.h.p. at speeds between 105 and 225 r.p.m., with reduced capacity at lower speeds, and it will be used at the works of Burmeister and Wain, Ltd., to test large diesel engines.

SCIENCE ESSAY COMPETITION.—In order to encourage research workers both in academic life and industry to appreciate the industrial significance of new discoveries and to exercise their ability in expressing their ideas at a policy-forming level, the publishers of *Research* have enabled the Scientific Advisory Board to offer prizes for papers discussing the possible industrial applications of some recent scientific investigation, whatever their origin. Papers, which should be about 3000 words in length, should be written in a manner which will enable an intelligent reader with a general scientific interest to appreciate the argument. Entries, which will be judged by a committee to be appointed by the Scientific Advisory Board, should reach the offices of *Research*, 4, 5, 6, Bell Yard, London, W.C.2, on or before April 30, 1953. Entries will be accepted only from persons actively engaged on research work in industry, Government or university laboratories. Prizes of £100 and £50 are offered for those entries which are adjudged to be best and second best, respectively. The Advisory Board has discretion to award an additional prize or prizes according to the quality of the contributions submitted. The judges' opinion must be regarded as final. Further details may be obtained on request from the offices of *Research*, at the address given above.

COURSE ON PRESTRESSED CONCRETE AT NOTTINGHAM UNIVERSITY.—The departments of civil and mechanical engineering at Nottingham University, with the assistance of the Cement and Concrete Association, have organised a course of lectures entitled "Prestressed Concrete—Design Principles and Methods." The course will consist of eleven weekly lectures, commencing January 7, 1953. The complete syllabus and enrolment form can be obtained from the University of Nottingham.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS.—Following its usual custom, the Institution of British Agricultural Engineers will hold a meeting at Earls Court, during the Smithfield Show and Agricultural Machinery Exhibition, which opens on Monday next. The meeting will take place in the Richmond Hall at Earls Court on Thursday next, December 11th, at 4.30 p.m. A paper entitled "Fans in Agriculture" is to be presented by Mr. William Cover and Mr. Raymond C. Dick.

OIL QUEST IN AFRICA.—The prospecting subsidiary of Anglo-Iranian Oil Company, Ltd., the D'Arcy Exploration Company, in conjunction with Royal Dutch Shell, have planned a geological and geophysical survey in quest of oil in East Africa. Based on Dares-Salaam, an air-photo survey of the coastal area of Tanganyika has started and will be extended to cover Zanzibar, Pemba Islands and parts of Kenya. Survey parties using the survey vessel "Burgan," will carry out ground surveys of islands off the East African coast.

INSTRUMENTS FOR RADIOACTIVE ISOTOPE APPLICATIONS.—A brochure on radioactive isotope applications has been published by the Scientific Instrument Manufacturers' Association (20, Queen Anne Street, W.1), in collaboration with the Atomic Energy Research Establishment at Harwell. The function of the brochure is to assist the potential user of radioactive isotopes in selecting electronic equipment to suit his needs. Details are given of the various detector elements and associated apparatus used for radioactive assay and radiation monitoring, together with the names and addresses of the manufacturers.

THE LATE MR. F. GURNEY.—We have learned with regret of the death of Mr. Frank Gurney, M.I.E.E., which occurred on November 27th at a London hospital, after a brief illness. Mr. Gurney, whose appointment as home sales manager was announced recently by Metropolitan-Vickers Electrical Company, Ltd., had been with that company for over thirty years. He was educated at Keighley Grammar School and received his engineering training with the Yorkshire Electric Power Company. Mr. Gurney was chairman of the North Midland Centre of the Institution of Electrical Engineers in 1941–2.

V.H.F. MULTI-CHANNEL RADIO EQUIPMENT.—In its publication No. R.E.B. 101 the Automatic Telephone and Electric Company, Ltd., Strowger House, Arundel Street, W.C.2, describes its v.h.f. wideband radio transmission equipment "VMS-VMR." The v.h.f. radio terminal equipment "VMS" and the repeater equipment "VMR" have been designed to provide for the transmission of multi-channel carrier groups, which conform to C.C.I.F. standards, over radio links in cases where the alternative use of overhead lines or underground cables is impracticable or uneconomical.

HISTORIC TELEPHONE.—Last Friday, November 28th, the Postmaster-General, Earl De La Warr, presented a historic telephone instrument to the Mayor of Tunbridge Wells, Councillor J. Crabtree. The telephone, which is of the magneto wall design, emblazoned with the coat of arms of the Royal Borough of Tunbridge Wells, is thought to be the only remaining relic of the 1901 Tunbridge Wells municipal telephone system, when the borough became the first municipal authority in the country to compete with the National Telephone Company. The instrument is in a remarkably good state of preservation and was recently recovered from the Pembury Waterworks, where it had been in daily use for fifty years. When the Tunbridge Wells municipal telephone exchange was opened in 1901 it catered for 229 square miles and had 330 subscribers.

AIR COMPRESSOR LUBRICATION.—The Vacuum Oil Company, Ltd., has published No. 5 of the company's technical series, under the title "Air Compressor Lubrication." The first section of the handbook generally reviews the theory and practice of air compression from theoretical and practical considerations and concludes with a note upon air compressor efficiencies. Two main categories of compressors, reciprocating and rotary, are considered and discussed separately. Technical descriptions of various compressors are given and accompanied by sectional diagrams, and the lubrication problems are examined, together with questions of preventive maintenance with respect to both categories of compressors. The handbook, which is mainly intended for the operating and maintenance engineer, is available free from The Vacuum Oil Company, Ltd., Caxton House, Tothill Street, London, S.W.1.

Personal and Business

MR. A. S. C. CHATTEY has been appointed managing director of A.C.V. Sales, Ltd.

MR. J. F. WHITFIELD, M.I.Mech.E., has been appointed general manager of B. Thornton, Ltd., Turnbridge, Huddersfield.

MR. W. C. FAHIE, M.Sc., A.M.I.E.E., states that he is no longer acting for Tinsley Industrial Instruments, Ltd., North Circular Road, N.W.10.

THE MINISTRY OF MATERIALS announces that the London area office of Timber Control will move on December 10th to Lacon House, Theobalds Road, W.C.1 (telephone, Chancery 4411).

THOS. FIRTH AND JOHN BROWN, Ltd., announces the removal of its London office to 11, Hamilton Place, Piccadilly, W.1 (telephone, Grosvenor 8781; telegrams, "Mesmeric, Audley, London").

THE TUDOR ACCUMULATOR COMPANY, Ltd., Dukinfield, Cheshire, has moved its London office to 137, Victoria Street, S.W.1 (telephone, Tate Gallery 0307; telegrams, "Subconical, Sowest, London").

MR. W. J. NICHOLLS, M.I.C.E., A.M.I.E.E., deputy chief electrical engineer of the Aluminium Wire and Cable Company, Ltd., has been elected an associate member of the American Institute of Electrical Engineers.

THE INTERNATIONAL CARGO HANDLING CO-ORDINATION ASSOCIATION announces that it has moved to new premises at 7, Victoria Street, London, S.W.1 (telephone, Abbey 2102; telegrams, "Harbinco, Fen, London").

PRITCHETT AND GOLD AND E.P.S. COMPANY, Ltd., Dagenham Dock, Essex, states that its London office has been moved to 137, Victoria Street, S.W.1 (telephone, Tate Gallery 9212; telegrams, "Storage, Sowest, London").

MR. HAROLD BURKE, M.I.Mech.E., has been appointed joint managing director of Concentric Manufacturing Company, Ltd., Tyburn Road, Birmingham, and a director of its subsidiaries, Rowmill Metals, Ltd., and T. Miller, Ltd.

THE BRITISH BROADCASTING CORPORATION has announced the retirement of Mr. R. J. Gilbert, engineer-in-charge of the Ottringham transmitting station. Mr. Gilbert joined the staff in 1924 as assistant maintenance engineer at Savoy Hill.

THE NEW ZEALAND SHIPPING COMPANY, Ltd., announces that Captain C. S. Broughton will retire at the end of the year and will be succeeded as marine superintendent by Captain J. J. Youngs, O.B.E., D.Sc., R.D., R.N.R., the deputy marine superintendent.

MR. JOHN CARTLAND, M.Sc., F.I.M., is retiring on December 31st from the boards of Fry's Metal Foundries, Ltd., and The Eyre Smelting Company, Ltd., Merton Abbey, London, S.W.19, after thirty-three years' service. He will continue to serve the companies as a consultant.

RILEY STOKER CORPORATION, of Worcester, Massachusetts, and John Brown and Co., Ltd., have concluded an agreement which secures to the latter company a licence to manufacture and sell to Riley Stoker Corporation's design components and complete steam generating plant and equipment for use in land power generating stations.

R. A. LISTER AND CO., Ltd., Dursley, states that by arrangement with the Wisconsin Motor Corporation, of Milwaukee, all spares and servicing for the Corporation's engines in this country will, in future, be handled by Power Units and Equipment, Standbrook House, 2–5, Old Bond Street, London, W.1, to which firm all inquiries should be addressed.

MR. L. M. C. ROBINSON, B.Sc., A.M.I.N.A., has been appointed naval architect to the Aluminium Development Association in place of Mr. J. Venus, A.M.I.N.A., who has resigned to take up an appointment with a firm of consultants. Mr. Robinson was until lately assistant shipyard manager at the Neptune Yard of Swan, Hunter and Wigham Richardson, Ltd.

Launches and Trial Trips

KING ARTHUR, cargo liner; built by Harland and Wolff, Ltd., for the King Line, Ltd.; length between perpendiculars 435ft, breadth moulded 59ft, depth moulded to shelter deck 39ft 9in, gross tonnage 5770; Harland-B. and W. single-acting, four-stroke diesel engine, six cylinders 740mm diameter by 1500mm stroke, 115 r.p.m., three 125kW diesel generators. Launch, November 19th.

HOPEMOUNT, oil tanker; built by Swan, Hunter and Wigham Richardson, Ltd., for the Hopemount Shipping Company, Ltd.; length between perpendiculars 526ft, breadth moulded 72ft 6in, depth moulded 40ft 6in deadweight 18,600 tons, load draught 31ft 5½in, service speed 14½ knots; Wallsend-Doxford two-stroke, opposed piston oil engine, six cylinders, 750mm diameter by 2500mm combined stroke, 8000 b.h.p. at 104 r.p.m., two multitubular Scotch boilers, two 75kW steam-driven generators, one 75kW diesel generator. Launch, November 19th.

SAXONHILL, oil tanker; built by the Netherlands Dock and Shipbuilding Company for Starros. S. Niarchos, Bermuda; length between perpendiculars 535ft, breadth moulded 73ft, depth 40ft; one set of N.D.S.M.-Parsons turbines, 7300 s.h.p., two N.D.S.M.-Babcock and Wilcox boilers supply steam at 450 lb per square inch, service speed 14·5 knots. Launch, November 22nd.

British Patent Specifications

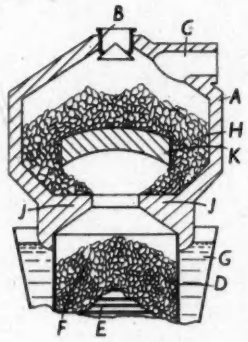
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

FURNACES

682,267. March 14, 1950.—GENERATING GAS FROM SOLID FUEL, Humphreys and Glasgow, Ltd., and Norman Henry Williams, both of 22, Carlisle Place, London, S.W.1. (*Inventor: Norman Henry Williams.*)

As the drawing shows, the generator has an upper chamber *A* with a central upper inlet *B* for the fuel and an outlet *C* for gas in the upper part of the chamber. There is also a lower chamber *D* which has a grate *E* supporting the lower bed of fuel *F*, and may have a water jacket *G*. The upper bed of fuel *H* is supported at its periphery by the annular shelf *J*, which forms a neck between the chambers. This

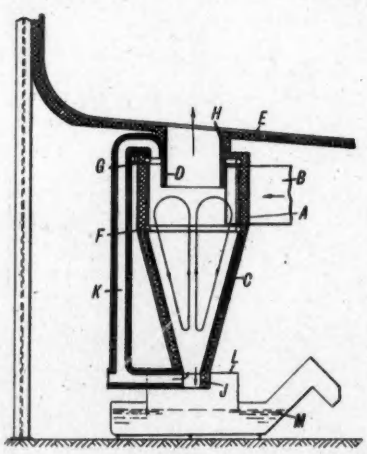


No. 682,267

upper bed of fuel is also supported by a central support *K*, which is shown at a higher level than the shelf. It is an important feature of the invention that the fuel from the upper bed *H* is fed to the lower bed *F* by dislodgement from the shelf *J*. It will be seen that the cross-sectional area of the chamber *A* is greater than that of the chamber *D*, with the result that during any upward gas flow, either blow or make, the rate of flow may be such as to "fluidise" fine particles from the lower bed in the space between the beds or to bring these fine particles into a state of suspension, but the rate of gas flow through the upper bed can be kept within such limits as to prevent fuel from being carried away out of the generator to an undesirable extent.—*November* 5, 1952.

682,033. September 29, 1950.—CYCLONE FURNACES, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4.

An object of the invention is the provision of a cyclone furnace with a top gas outlet in which loss of unburned combustibles is lessened or avoided. As the drawing shows, the combustion chamber of the cyclone furnace includes an upper, substantially cylindrical part *A*, having at least one inlet *B* for the



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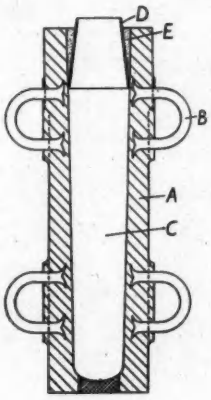
fuel and air mixture opening tangentially to the inner surface of the upper part and a downward-tapering conical part *C*. Extending through an upper wall of the combustion chamber is a concentric gas outlet throat *D* terminating in the floor *E* of the secondary combustion chamber, which is lined with cooling tubes. The parts *A* and *D* have internal cooling tubes connected into the circulatory system of the boiler. The peripheral wall of the part *A* is lined with vertical tubes extending between headers *F* and *G*, and the part *C* is formed with a tubular helical lining. The outlet throat *D* is also provided with a tubular lining *H*. At the lower end of the furnace is a cylindrical extension *J* having, in its sides, an air supply port communicating with a duct at the outer end of which is a register valve. Connected at one end to the duct and communicating with the top of the combustion chamber is a duct *K*. The extension *J* projects within and makes an airtight joint with a bell housing *L*, the walls of which dip into the water of an ash trough *M*, so that suction at the extension is fully effective. During operation, air and granular fuel enter the combustion chamber through the tangential inlet or inlets *B* and whirl within the combustion chamber. The major part of the slag is deposited on the combustion chamber walls in molten form and flows down the walls and through the extension *K* into the ash trough *M*. The gases pass through the throat *D* into the secondary combustion chamber. Owing to the form of the cyclone furnace, there is produced a secondary gas circulation with downward movement adjacent the conical surface of the part *C* and upward movement near the axis of it. The upward gas flow tends to prevent fines in suspension from passing out through the extension *J*. A suction is produced at the extension which may be used for drawing in combustion air in amount controlled by the valve. Hot gases mixed with the air in the ducts serve to heat the air sufficiently to avoid undesirable cooling of the molten slag flowing from the combustion chamber.—*November* 5, 1952.

METALLURGY

682,311. February 18, 1948.—MOULDING OF METAL INGOTS, The Clyde Alloy Steel Company, Ltd., Craigneuk Works, Motherwell, Lanarkshire, Scotland. (*Inventor: James Nicol.*)

This invention relates to the moulding of ingots of mild and alloy steels. The mould *A* has thick walls with lifting eyes *B* and the ingot moulding space *C* carries at the top the frusto-conical thin sheet metal sleeve *D*. The walls of the moulding space diverge slightly in the upward direction and the conical sleeve seats snugly against these walls. The space between the sleeve and the walls at *E* is filled with heat-storing medium in the form of sand. The mould will generally be filled with metal to a level corresponding to the top of the mould. The thin walls of the metal



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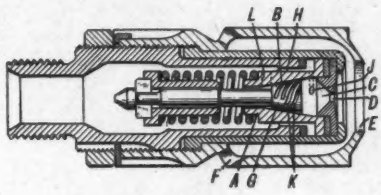
sleeve leave no appreciable shoulder round the ingot and the waste after rolling or forging may be reduced from, for example, 25 per cent of the ingot in the previous methods to, for example, 10 per cent. The interior walls of the ingot moulds diverge slightly upwards, and the sleeve, tapering upwards, ensures a neat fit with the inner walls of the mould and it sinks downwards somewhat as the mould cools; thus "hanging" by passage of liquid metal between the sleeve and the mould is avoided. Furthermore, the metal sleeve does not store moisture which would cause generation of hydrogen as with firebrick constructions.—*November* 5, 1952.

GAS TURBINES

682,113. July 28, 1950.—BURNER NOZZLES, H. M. Hobson, Ltd., Africa House, Kingsway, London, W.C.2. (*Inventors: Thomas Simpson and John Ernest Walford.*)

The invention provides a burner nozzle particularly, though not exclusively, for use in a gas turbine. As the drawing shows, the body of the nozzle, which consists of three parts screwed together, has an inlet for fuel at its rear end. Fitted into the front end of the body is a tubular valve guide *A*, having on its rearward-tapering end a valve seat *B*. In the forward end of the valve guide is a swirl chamber *C*. Over the forward end of the valve guide is fitted a cap, having a central jet *D* axially aligned with the guide. The fuel from the jet emerges from a hole *E* in the forward section of the nozzle body, which is provided with holes *F* for admitting air. Inside the tapering portion of the valve guide is the conical valve head *G*, which is held seated on the seating by a spring. When the pressure of the fuel entering the rear inlet is small, the valve remains closed and the fuel flows through two passages *H* between the valve guide *B* and the valve member, and thence, through two



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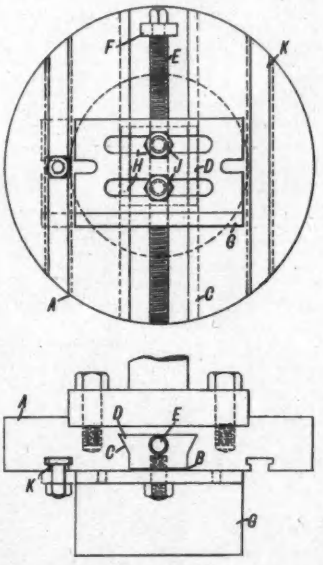
tangential swirl ports *J* in the valve guide, into the swirl chamber and out through the jet. At a predetermined pressure of the entering fuel, the valve lifts from its seating *B* allowing a further supply of fuel to flow through the valve into the swirl chamber *C* via helical grooves *K* in the valve head *G*. These helical grooves impart a swirling movement to this additional supply of fuel and this swirling movement is accentuated by the fact that the fuel from the exterior of the valve guide *A* passes to the rear end of the valve seat *B* through two tangential inlet ports *L* in the valve guide.—*November* 5, 1952.

MACHINE TOOLS

682,014. March 24, 1950.—FACE PLATES FOR LATHES, Gerald Clair Tozer, 7, Cadogan Avenue, Lindley, Huddersfield, and Geoffrey Smith, 6, Douglas Avenue, Dalton, Huddersfield.

Referring to the drawings, a face plate *A* has, extending diametrically across the front face, a groove *B*, the edges of which constitute angular guides *C*, along which a block *D* is slid by means of a screw *E* journalled at its ends in the face plate and passing through a threaded opening in the block. A strap member *F* forms a journal for the screw and prevents its endwise movement. An angle plate *G* is provided with a pair of parallel elongated slots *H* extending at right angles to the axis of the central screw, and through these elongated slots set screws *J* enable the angle plate to be secured to the block in



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any desired position within the limit determined by the length of the slots. By appropriate adjustment of the position of the slidable block *D* and of the position of the angle plate *G*, a workpiece can be secured to the face plate in any desired position in relation to the centre of rotation of the work spindle. The front face of the face plate has a pair of "T" slots *K*, which enable the angle plate to be more effectively secured to the face plate when off-centre work is to be done.—*November* 5, 1952.

Codes of Practice

WATER SUPPLY

Code 310. The Council for Codes of Practice for Buildings has now issued in final form Code 310, "Water Supply." It has been drawn up by a committee convened by the Institution of Water Engineers on behalf of the Council, and is a revision, following comments received, of the draft code previously issued.

The code deals with water supplies to all kinds of buildings, either directly from wells, boreholes, rivers and similar natural sources, or through the agency of a public water undertaking. It strongly recommends that, in all but the simplest cases of connection to a water undertaking's mains, expert advice should be obtained when choosing the source of supply and planning the system. Detailed information is given as to the preliminary steps required and the collaboration necessary before embarking on a scheme of water supply, noting the differences of procedure when the water is obtained directly from natural sources or through a public water undertaking. A full list of British Standards is included which covers all the materials, appliances and components used in water supply work.

The design section of this code is divided into five parts. The first part deals with "Supply," in which is discussed at some length all the sources of water, together with notes on quality and sampling. The next part deals with "Treatment" and includes information on methods of filtration, sterilisation and softening, with recommendations as to choice of method in various circumstances. The rest of the "Design" section, under the headings "Conveyance," "Storage" and "Fittings and Appliances," deals very fully with the mains, service pipes, tanks, cisterns and other fittings and appliances required to convey water from its place of treatment to its place of draw-off by the user.

The section "Work on Site" covers methods and processes employed in laying and installing a system of water supply, the main subjects being the jointing of pipes, laying of mains, connection of service pipes and distribution pipes, fixing of pipes to buildings, lagging of pipes and cisterns, arrangement of draw-off taps and sterilisation of installation prior to being taken into use. Notes on the inspection and testing of installations are given, and there is a series of tables. Copies may be obtained from the British Standards Institution, 24–28, Victoria Street, London, S.W.1, price 6s.

Contracts

VICKERS-ARMSTRONGS, LTD., has received a contract from Trans Canada Air Lines for fifteen "Viscount" propeller-turbine airliners. The approximate value of this order, including spares, is £4·1 million (11·5 million Canadian dollars). Deliveries are to be completed by April, 1955.

CANADIAN PACIFIC STEAMSHIPS, Ltd., has placed an order with the Fairfield Shipbuilding and Engineering Company, Ltd., to build a passenger and cargo liner for the Liverpool-Canadian service of the company. The ship, which will have a gross tonnage of 22,500 and a service speed of 21 knots, will have accommodation for 150 first-class and 900 tourist-class passengers and be equipped with a Denny-Brown stabiliser.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Dec. 8th.—CENTRAL LONDON BRANCH: St. Ermin's Hotel, Caxton Street, London, S.W.1, "Fluid Couplings for Electric Motor Drives," E. C. Farrer, 6.45 p.m.——N.W. LONDON BRANCH: Prince of Wales Hotel, Kingsbury, "The Maintenance of Electric Lifts," 8 p.m.

Tues., Dec. 9th.—BOLTON BRANCH: Balmoral Hotel, Bradshawgate, Bolton, "H.R.C. Fusegear," E. Jacks, 7.30 p.m.

Wed., Dec. 10th.—BRADFORD BRANCH: Midland Hotel, Bradford, "Miniature Circuit Breakers," Dorman Smith, 7.30 p.m.——LEEDS BRANCH: City Museum, Leeds, 1, "Radio Active Isotopes in the Service of Medicine," F. W. Spiers, 7.30 p.m.——PRESTON BRANCH: Bull and Royal Hotel, Preston, "Pyrotenax Cables," R. B. Barritt, 7.45 p.m.

Thurs., Dec. 11th.—KENT BRANCH: Royal Star Hotel, Maidstone, "Radio Aids to Navigation," E. Fennessy, 8 p.m.

Fri., Dec. 12th.—CREWE BRANCH: Copeland Arms Hotel, Glebe Street, Stoke, Visit by Member of the Executive Council, 7.30 p.m.——LIVERPOOL BRANCH: Lecture Theatre Service Centre, 9, Whitechapel, Liverpool, "The Dorman Miniature Circuit Breaker," H. W. Wolff, 7.30 p.m.

Mon., Dec. 15th.—N.W. LONDON BRANCH: Prince of Wales Hotel, Kingsbury, "The Maintenance of Electric Lifts," 8 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Dec. 9th.—W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, programme of Technical Films, 7.15 p.m.

Wed., Dec. 10th.—LONDON SECTION: School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "The Production of Television Receivers," Frank Allen, 6.30 p.m.——N.E. SECTION: Institution of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "The Development of the Radio and Electronics Industry in India," G. D. Clifford, 6 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., Dec. 6th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, Annual General Meeting, 3 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-Day, Dec. 5th.—BATH AND BRISTOL CENTRE: S.W. Electricity Board Lecture Theatre, Old Bridge, Bath, "The Architect's Approach to Artificial Illumination," R. G. Cox, 7 p.m.——HUDDERSFIELD GROUP: Electricity Showroom, Market Street, Huddersfield, "Lighting Ideas for the Home," Miss M. D. Wardlaw, 7.15 p.m.

Mon., Dec. 8th.—SHEFFIELD CENTRE: The University, Western Bank, Sheffield, 10, "Lighting in Crime Detection," C. Harold Edlin, 6.30 p.m.

Tues., Dec. 9th.—LONDON MEETING: Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, "Visual Fatigue," H. C. Weston, 6 p.m.——STOKE-ON-TRENT GROUP: Midlands Electricity Board, 31, Kingsway, Stoke-on-Trent, "Colour in Industry," J. H. Nelson, 6 p.m.

Thurs., Dec. 11th.—MANCHESTER CENTRE: N.W. Electricity Board, Town Hall Extension, Manchester, "A Short Investigation into Stroboscopic Effect," E. Smith, 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Dec. 8th.—DUNDEE BRANCH: Mathers Hotel, Dundee, "Maintenance Organisation—the American and British Approach Compared," T. C. Robinson, 7.30 p.m.

Tues., Dec. 9th.—E. LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, "Alterations to the Guardian Building," P. G. Fairhurst, 7.15 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, Five Short Films by Scottish Oils and Shell-Mex, Ltd., 7 p.m.——GLASGOW BRANCH: Engineering Centre, 351, Sauchiehall Street, Glasgow, "Power Factor Correction," Hugh Ferguson, 7 p.m.

Wed., Dec. 10th.—E. MIDLANDS BRANCH: Welbeck Hotel, Nottingham, "The Diesel-Electric Locomotive," F. D. Lester.

Thurs., Dec. 11th.—NEWCASTLE UPON TYNE BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Pile Driving," R. Stelfox, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Dec. 10th.—LANCASHIRE BRANCH: Engineers' Club, Albert Square, Manchester, Film and Report, "Flow of Metal," G. W. Nicholls, 7 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Sat., Dec. 6th.—The Christian Institute, 70, Bothwell Street, Glasgow, "Overheads," C. W. Spence, 10.30 a.m.

INSTITUTE OF INDUSTRIAL SUPERVISORS

Thurs., Dec. 11th.—LONDON S.E. SECTION: The Polytechnic, Woolwich, "Labour Supply and its Problems in S.E. London," W. G. Frend, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Dec. 9th.—85, Minories, London, E.C.3, "Some Unusual Ship and Machinery Defects: Their Investigation and Cure," 5.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Dec. 10th.—Manson House, 26, Portland Place, London, W.1, "Liquefied Petroleum Gases," "Production," E. S. Squire; "Distribution," S. Shaw; "Applications," T. H. Taylor, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Dec. 9th.—MIDLANDS CENTRE: Crown Inn, Broad Street, Birmingham, "The Running Maintenance of Fuel Injection Equipment," A. J. Rowley, 7.30 p.m.

Wed., Dec. 10th.—E. MIDLANDS CENTRE: Mechanics Institute, Nottingham, "Straight Mineral Oils as Opposed to Detergent Oils," . C. Hunt, 7.30 p.m.

Thurs., Dec. 11th.—S. WALES GROUP: S. Wales Institute of Engineers, Park Place, Cardiff, "Low Viscosity and Detergent Oils," H. A. Nida, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Thurs., Dec. 11th.—Smithfield Show and Agricultural Machinery Exhibition, Richmond Hall, Earl's Court, London, "Fans in Agriculture," W. Cover and R. C. Dick, 4.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Sat., Dec. 6th.—MIDLANDS BRANCH: The University, Edmund Street, Birmingham, "Efficiency of the Kaskade Distillation Column," F. H. Garner, S. R. M. Ellis and A. J. Hugill, 3 p.m.

Tues., Dec. 9th.—Geological Society, Burlington House, Piccadilly, London, W.1, "The Use of Sulphuric Acid in a Totally Enclosed System," J. L. Edgar, 5.30 p.m.

Fri., Dec. 12th.—GRADUATES' AND STUDENTS' SECTION: Caxton Hall, Westminster, London, S.W.1, "The Production of Chlorine," C. R. Black, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 9th.—WORKS MEETING: Great George Street, Westminster, London, S.W.1, "Economic Use of Heavy Earth-Moving Equipments and Field Maintenance Thereof," B. J. Meighan, 5.30 p.m.

Thurs., Dec. 11th.—YORKSHIRE ASSOCIATION: The Guildhall, Hull, "Economic Use of Heavy Earth-Moving Equipments and Field Maintenance Thereof," B. J. Meighan, 6.15 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "The Practical Design of Rigid Frame Distillation Structures," G. T. Layton, 6.30 p.m.

Fri., Dec. 12th.—YORKSHIRE ASSOCIATION: Royal Victoria Station Hotel, Sheffield, "Economic Use of Heavy Earth-Moving Equipments and Field Maintenance Thereof," B. J. Meighan, 7 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Dec. 8th.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "The Maintenance of Electrical Equipment," opened by R. H. Cobbold, 5.30 p.m.

Tues., Dec. 9th.—MEASUREMENTS AND SUPPLY SECTION: Savoy Place, London, W.C.2, "Voltage Transformers and Current Transformers Associated with Switchgear," W. Gray and A. Wright, 5.30 p.m.——LONDON STUDENTS' SECTION: George Hotel, Reading, Chairman's Address, "The Protection of Running Buses," B. L. A. Ellings, 7 p.m.——N. MIDLAND CENTRE: British Electricity Authority, 1, Whitehall Road, Leeds, 1, "Post-Graduate Activities in Electrical Engineering," W. J. Gibbs, D. Edmundson, R. G. A. Dimmick and G. S. C. Lucas, 6.30 p.m.

Wed., Dec. 10th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The B.B.C. School, Evesham," and "The Post Office School, Stone," opened by K. R. Sturley and H. R. Harbottle, 6 p.m.——SOUTHERN CENTRE: S. Dorset Technical College, Weymouth, "Principles of Colour Television," J. H. Mole, 6.30 p.m.——N. SCOTLAND SUB CENTRE: Caledonian Hotel, Aberdeen, "The Logical Approach to the Problem of Space Warming," D. H. Parry, 7.30 p.m.

Thurs., Dec. 11th.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Royal Festival: Electrical Installation," J. G. Hunter, 5.30 p.m.——N. SCOTLAND SUB-CENTRE: Royal Hotel, Dundee, "The Logical Approach to the Problem of Space-Warming," D. H. Parry, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 5th.—GENERAL MEETING: Storey's Gate, St. James's Park, London, S.W.1, "An Experimental Investigation in the Redrawing of Cylindrical Shells," S. Y. Chung and H. W. Swift; "An Experimental Investigation of the Yielding of Strip Between Smooth Dies," A. B. Watts and Hugh Ford, 5.30 p.m.

Mon., Dec. 8th.—E. MIDLANDS BRANCH AND DERBY A.D. CENTRE: Rolls-Royce Welfare Hall, Nightingale Road, Derby, "Gas Turbine Development," B. E. G. Forsling, 7 p.m.

Tues., Dec. 9th.—AUTOMOBILE DIVISION: Storey's Gate, St. James's Park, London, S.W.1, Discussion on "Research and the Engineering Process," H. E. Merritt, 5.30 p.m.——SOUTHERN CENTRE: Technical College, Brighton, Film Evening, 6.30 p.m.——S. WALES BRANCH: Mackworth Hotel, Swansea, "Present and Projected Developments of Gas Supplies in the S. Wales Area," E. M. Edwards, 6 p.m.

Wed., Dec. 10th.—E. MIDLANDS BRANCH, GRADUATES' SECTION: Art Gallery, Derby, "Development and Operation of Steam Turbines," A. P. Houghton, 7.15 p.m.——SCOTTISH BRANCH: Technical College, Dundee, "Materials Handling," A. Roebuck, 7.30 p.m.

Thurs., Dec. 11th.—WESTERN A.D. CENTRE: Park Hotel, Cardiff, "Research and the Engineering Process," H. E. Merritt, 6.45 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

To-day, Dec. 5th.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The London-Wenvoe Experimental Radio Link for Television," W. J. Bray, R. L. Corke and R. W. White, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Dec. 5th.—W. WALES SECTION: Y.M.C.A., St. Helen's Road, Swansea, "Administrative Problems of Industry," Sir Patrick Hannon, 7.30 p.m.

Mon., Dec. 8th.—COVENTRY GRADUATE SECTION: Geisha Cafe, Hertford Street, Coventry, "Industrial Law—Legal Aspects of Factory and Production Management," H. Peter Jost, 7.30 p.m.——SHEFFIELD SECTION: Royal Victoria Station Hotel, Sheffield, "Modern Developments in Electric Welding," H. G. Taylor, 6.30 p.m.——YORKSHIRE SECTION: Hotel Metropole, King Street, Leeds, 1, "Difficulties and Developments in Deep Drawing and Pressing," J. D. Jevons, 7 p.m.

Tues., Dec. 9th.—DUNDEE SECTION: Queen's Hotel, Dundee, "Apprentice Training," W. Heigh, 7.30 p.m.

Wed., Dec. 10th.—CORNWALL SECTION: Technical College, Treveron Park, Pool, Redruth, Cornwall, "Control of Quality in Production Engineering," J. H. Williams, 7.15 p.m.——HALIFAX GRADUATE SECTION: White Swan Hotel, Halifax, "Electronic Control of Machine Tools," R. Parr, 7.15 p.m.——LIVERPOOL SECTION: Radiant House, Bold Street, Liverpool, "Increased Productivity by Machine Shop Practice," A. Cameron, 7.30 p.m.——PRESTON SECTION: Crown Hotel, Market Place, Blackburn, "Current Problems of Management," M. Seaman, 7.15 p.m.

Thurs., Dec. 11th.—LONDON SECTION: Royal Empire Society, Northumberland Avenue, London, W.C.2, "Modern Finishing Processes," K. W. Abineri, 7 p.m.

Fri., Dec. 12th.—EASTERN COUNTIES SECTION: Public Library, Ipswich, "The World's Largest Walking Dragline—Its Manufacture and Assembly," C. Mc. L. Cameron and F. Clifton, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Dec. 5th.—WESTERN COUNTIES BRANCH: Geology Lecture Theatre, The University, Bristol, "The Design and Erection of Television Masts," P. J. Ward, 5.30 p.m.

Thurs., Dec. 11th.—11, Upper Belgrave Street, London, S.W.1, "Prestressed Concrete Bridges and Other Structures," Donovan H. Lee, 5.55 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Tues., Dec. 9th.—Royal Society of Tropical Medicine and Hygiene, 26, Portland Place, London, W.1, "Matching Rubber Compounds," N. C. H. Humphreys; "Recent Applications of Physics to Inspection Methods in the Rubber Industry," G. F. Morton and P. Hatfield, 7 p.m.

IRON AND STEEL INSTITUTE

Thurs., Dec. 11th.—IRON AND STEEL ENGINEERS' GROUP: 4, Grosvenor Gardens, London, S.W.1, Twentieth Meeting, 9.30 a.m. to 12.30 p.m. and 1.45 p.m. to 4 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 5th.—Townsend House, Greycoat Place, London, S.W.1, Film Evening, "Grain Drying," introduced by T. C. Bailey, 7 p.m.

Mon., Dec. 8th.—SHEFFIELD AND DISTRICT SECTION: Livsey Clegg House, Sheffield, "The Application of Automatic Control," A. Muir, 7.30 p.m.——N.W. SECTION: Geographical Society, 16, St. Mary's Parsonage, Manchester, "Modern C.I. Engines," C. R. Spencer and P. Threlfall, 7 p.m.

Wed., Dec. 10th.—MIDLAND SECTION: WOLVERHAMPTON DISTRICT MEETING: Stewarts and Lloyds, Ltd., Bilston, Staffordshire, "High Frequency Induction Heating," H. Knight, 7 p.m.

Fri., Dec. 12th.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Presidential Address, "The Air and the Future," F. R. Banks, 7.30 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., Dec. 11th.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "Friction and Lubrication," D. Tabor, 6.30 p.m.

NEWCOMEN SOCIETY

Wed., Dec. 10th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "The Decapod Locomotive of the Great Eastern Railway," W. O. Skeat, 5.30 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Dec. 12th.—Literary and Philosophical Society's Lecture Theatre, Newcastle upon Tyne, "The Application of Research to the Gas Turbine," Hayne Constant, 6.15 p.m.

STOKE-ON-TRENT ASSOCIATION OF ENGINEERS

Wed., Dec. 10th.—Midlands Electricity Board, Back Glebe Street, Stoke, "Automatic Controls," J. C. Farquhar, 7 p.m.